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With special reference to Asia and the Far East

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REPORT OF THE FIRST GROUP
OF EXPERTS ON PROGRAMMING TECHNIQUES



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PREFACE

This report on the techniques of programming economic development was prepared by a group of five experts who were appointed by me in accordance with the Commission's decision at its fourteenth session (Kuala Lumpur, March 1958) "that the Working Party (on Economic Development and Planning) should constitute a sub-group of experts in the near future to consider some specific aspects of the techniques of programming economic development."¹

The report represents the unanimous views of its authors who acted in their personal capacities and whose recommendations, as set out in chapter IX, are put forward on their own responsibilities.

The group was composed of the following: Mr. Gamani Corea, Secretary to the National Planning Council and Director of the Planning Secretariat, the Government of Ceylon; Mr. Dwarkanath Ghosh, Chairman of the Programmes Evaluation Organization of the Planning Commission, the Government of India; Mr. Benjamin Higgins, Professor of Economics and Chairman of the Department of Economics, University of Texas; Mr. Shinichi Ichimura, Assistant Professor at the Institute of Social and Economic Research, Osaka University; and Mr. Jan Tinbergen, Professor of Development Planning at the Netherlands School of Economics, Rotterdam. At the invitation of the group, Professor Jan Tinbergen acted as Chairman and Professor Dwarkanath Ghosh as Vice-Chairman.

With the constitution of the group of experts, ECAFE's work in the field of economic development planning has entered a new stage. The significance of this new stage lies in the recognition of the need that some expert technical guidance should be provided to the Governments of the countries in Asia and the Far East to plan more effectively the economic development of their countries. This need has long been felt in this region. In the previous four annual sessions of ECAFE's Working Party on Economic Development and Planning, the problem of resource allocation was recognised as basic to economic development planning. But it could not undertake detailed and systematic consideration of the most efficient approach to programming techniques which was so essential in dealing

¹ *Annual Report of the Economic Commission for Asia and the Far East to the Economic and Social Council*, March 1957 - March 1958 (E/3102), paragraph 286.

with this problem mainly because of its size as well as its natural orientation towards broader policy aspects. The work of the expert group thus constitutes an important addition to the continuing work which ECAFE is doing in the field of economic development and planning. I hope that the work initiated by this expert group will be found useful by the Member Governments, and I commend this report to the attention of the Commission.

On behalf of the United Nations, I wish to express my deep appreciation to the experts of the group for their contribution, and to thank the institutions with which the experts were associated for their readiness to release them from their normal duties to undertake this important task. I should also like to take this opportunity to thank the United Nations Bureau of Technical Assistance Operations for its help in establishing the expert group.

U NYUN,

Executive Secretary

22 December 1959

Letter of transmittal to the Executive Secretary

We have the honour to submit herewith the report of the First Group of Experts on Programming Techniques of the ECAFE. It is the outcome of our meetings at Bangkok held during the four weeks commencing 7 July 1959, and of discussion by correspondence. Professor J. Tinbergen was selected by the Group to be its Chairman and Professor D. Ghosh its Vice Chairman.

We were appointed with the following terms of reference:

"To prepare, in 1959, a report outlining the most efficient and practical approach to economic development programming techniques, with special reference to growth models as a tool of development programming in countries of the ECAFE region, and for this purpose: (a) to examine various types of growth models as to their usefulness and applicability in the countries of Asia and the Far East and to make recommendations on the construction and use of such models considered likely to be generally useful to the countries in economic development planning, (b) to determine the types of economic and other information and data required for the construction and use of such models, and (c) to draw up a recommended list of priority tasks for future expert groups."

We have tried to meet these terms, as far as possible, in the short time at our disposal. We have discussed in the body of our report a series of growth models, starting with the simplest and proceeding to increasingly complex ones. This arrangement was partly determined by the development of our subject, but we had also in mind the varying stages of planning and of statistics, which the different countries of the region have reached. The mathematical treatment of the models will be found in the Appendices.

The different chapters of the report indicate the data that are necessary for the construction of the models dealt with in them. We have, besides, recommended the collection of some data by international organizations, which, we feel, would greatly facilitate the use of the technique of programming by the countries of the region in building and evaluating their development plans.

We have recommended as priority tasks three studies which the next two groups of experts may take up.

We have made two recommendations which are not covered by a strict interpretation of our terms of reference. We consider them however

to be of fundamental importance to the achievement of our primary objective, viz. dissemination of the knowledge of and skill in programming techniques in the region. We have suggested the preparation of a Handbook on Programming Techniques and the organization of training courses in the subject for the benefit of the staffs of the planning bodies of the countries in the region.

There is one other matter on which also we have made our suggestion. At its fifteenth session held on 9-19 March 1959, the Economic Commission for Asia and the Far East endorsed the suggestion advanced at the Fourth FAO Regional Conference for Asia and the Far East for a joint regional meeting of experts on problems of target setting in agriculture, and noted that this subject might be taken up under the programme of the newly established Working Group of Experts on Techniques of Programming.

The Commission's suggestion has not been included in our original terms of reference. It was, however, brought to our notice soon after we had assembled at Bangkok. We discussed it with the officers of the Joint ECAFE/FAO Agriculture Division of the secretariat. Our conclusions have been incorporated into our list of recommendations.

We want to acknowledge our gratitude to the members of the Research and Planning Division of the ECAFE secretariat for participating in our discussion and helping us with their knowledge and understanding of the region. We would also like to thank our secretaries for their excellent service.

Yours respectfully,

D. Short

J. Timbergen

Samari Brea

Shimichi Shimizu *Benjamin Higgins*

Bangkok, Thailand
6 December 1959

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Chapter I

INTRODUCTION

1.1 Introductory

In recent years, most countries of the region have been formulating and implementing development plans. In the course of this process, official planning agencies have gained valuable experience in the techniques and methods of planning. At the same time, there has been much useful discussion of planning techniques outside these agencies—in universities, research centres, and so on. Inevitably, much of this latter discussion has been removed from the work of official planning agencies, and has at different times and places centred around particular problems. Nevertheless, a stage has now been reached where some of the approaches and techniques that have been evolved could be of direct benefit in practical planning. The purpose of this report is, therefore, to review and sum up these developments, and to present them in a form that will serve as a guide for official planning bodies, especially those in the ECAFE region, in preparing a comprehensive and logically consistent plan. The form of presentation of this report has largely been guided by the need to extend its usefulness to the widest range of readers. Hence mathematical forms of expression have, as far as possible, been excluded from the body of the report and confined to appendices.

1.2 The applicability of programming

The extent to which programming techniques could in practice be applied in individual countries depends on several factors. These include the stage of planning that has already been reached, the availability of the requisite data, the quality and size of the agencies responsible for planning, and the techniques themselves. However, the applicability of these techniques is by no means confined to the more developed countries. Many are relatively simple, and can be mastered by most planning agencies in a relatively short time. Moreover, they yield useful results even when based on statistical and other data which are only in the nature of reasonable approximations. At times even data derived from the experience of other countries can be used. In any event, it is through actual attempts to use existing data, however imperfect, that a stimulus is provided for their improvement.

Programming, when undertaken, should be carried out in a systematic way, and with the aid of methods preventing the planner from running into inconsistencies. In other words, use should be made of economic "models", which reflect a state free from internal contradictions. Many other conditions will, of course, have to be met in addition; these will be discussed later. The purpose of creating models for development planning, however, is precisely to provide the framework of a sound and logical arrangement for the organization of the research activities needed in any form of programming.

Some of the techniques of programming discussed in this report are so generally valid that they apply to countries with widely different economic systems. Thus, input-output techniques, to be discussed later (see chapters V and VI), are applied in centrally planned and other economies alike; in the former, usually under the name of the "balance method". There are several other techniques applicable to both types of economies. It is hoped, therefore, that the report is useful for countries of widely varying structures.

1.3 Planning in stages

The order in which the various techniques of programming are discussed in this report corresponds broadly to their complexity. It also represents the sequence in which they may logically be applied in practical planning. It should be emphasized, however, that programming may be undertaken in stages, drawing the main lines first and specifying details at a later stage. Useful results can be obtained at each stage and need not await the use of the more advanced techniques. At the same time, it is not suggested that planning agencies should necessarily follow the sequence set out here. The degree of detail aimed at and the actual techniques applied would depend on circumstances peculiar to individual countries. Less advanced techniques imply the use of simpler models, of a so-called marco-economic character, while advanced techniques make it possible to construct micro-models in which more detailed information on individual sectors is used. While macro-models are less reliable than micro-models, they can be made as helpful as possible by the use of information on individual sectors in preparatory partial research of a more pedestrian type.

1.4 Partial plans

A situation common to most countries in the initial stages of planning is one in which a series of development projects is being formulated and implemented by various government agencies. The extent of co-ordination

or planning in respect of these projects is usually limited to that imposed by Treasuries in connexion with annual budgets. It is therefore understandable that the early work of practical planning has often centred around the "ordering out" of departmental programmes and projects, and their fusion into a single whole. It is essentially the results of these exercises that have been embodied in the early development plans of many countries. Although the activities of the private sector are sometimes covered in a general way, these plans are primarily partial in scope. They present, in varying detail, what would amount to long-term or medium-term capital budgets for the public sector.

It must be recognized that, despite the limitations inherent in such an approach, these partial plans serve some useful purposes. They help to focus public attention on planning and development; they provide a useful framework of priorities for financial policy and budgeting; and they emphasize problems of implementation at an early stage, by providing a basis for progress reports. Despite these advantages, however, the limitations to this kind of approach are real. Because they are partial in scope, and because they have not been formulated on the basis of overall programming, these plans may not reflect the real development needs of the economy as a whole. There would, for instance, be little to ensure that the magnitude of development they provided for corresponded to even the minimum requirements for economic growth. The projects which comprise these plans have not been appraised and selected by the yardstick of national costs and benefits. In addition, these projects and programmes may not be mutually consistent and balanced, and may thus lead to scarcities and bottlenecks which hamper development.

For all these reasons, planning agencies should proceed beyond the initial stages as early as possible. The application of programming techniques provides a means of bringing out clearly some of the limitations mentioned above.

1.5 The need for qualitative exploration

A large part of the techniques of programming discussed in subsequent chapters is concerned with quantitative estimation. This does not mean, however, that the use of the more qualitative kind of analysis in the work of planning is denied or overlooked. Some attention may therefore be given first to the latter type of analysis.

It is useful for planners to formulate, at an early stage, what may be called the broad strategy of development appropriate to the country concerned. This formulation need not involve the construction of precise

and elaborate models, but could be based on a general appraisal of the main economic facts peculiar to these countries. The purpose would be to clarify and set out the particular patterns and directions of future development.

It is not possible, on account of the very nature of this approach, to outline any precise or clearly defined methods. The broad aim should be to build up as clear as possible an impression of the structure which a particular economy may be expected to attain in the long term. This structure would, to a large extent, depend on factors specific to the country. It would, for instance, vary between large and small countries, between countries differently endowed in respect of natural resources, and between those with differing prospects of population growth.

The chief elements behind such an approach may perhaps be briefly illustrated. For example, a country with a rapidly rising population will need to determine the avenues of future employment which it could successfully create. Where the traditional fields of productive activity have been domestic agriculture or plantation crops or both, it is logical to determine first whether there is any scope for their further expansion. Such possibilities may be found to exist, and some early estimates of the magnitudes involved and the time needed to achieve them may be feasible. These magnitudes may, however, prove to be limited, on account of physical factors, such as the availability of additional land and the technical limits to a further intensification of agriculture. In the light of an appraisal of these limits and the expected increase in the work force, some impression can be obtained of the scale of expansion required in other fields, as well as of the relative urgency of such expansion.

Where, as is likely, industrialization is the most important of the new fields of expansion, it will be important to consider the type of industrial structure appropriate to the country in question. A small country not richly endowed with industrial materials will have to base its industrial development on the import of these materials. Furthermore, although there may exist some scope for commencing industrialization on the basis of the domestic market, the extent of such industrialization may not suffice to absorb the growing workforce. The importance of establishing industries for export will then be apparent. Again, a small country may not be able to sustain a capital goods sector and may have to import the machinery and equipment it needs. In order to obtain the foreign exchange required, much emphasis may have to be placed on the further expansion, where possible, of such exports as plantation crops, and on the domestic production of import-saving products. The relevance of programmes in the field of agriculture in a strategy of development aimed at industrialization is thereby underlined.

The advantages of an initial appraisal of this sort are real. Without having to depend on too elaborate calculations, it gives planners an idea of priorities. In this way, it helps in the selection of the important fields or sectors on which to concentrate the further work of planning. Technical enquiries regarding the physical potential for development in these fields may be initiated, and steps taken to formulate specific measures and projects for their exploitation. The data revealed by these enquiries could provide much of the material needed for the subsequent application of more advanced methods of programming. In addition, an approach on these lines provides a guide in directing the work of development during the interim period pending the completion of a carefully elaborated plan.

A qualitative exploration of the kind discussed here only provides a preliminary framework and must, of course, be followed up by the application of more precise methods of planning. Once the general pattern and direction of future development has been established, it is necessary to ensure that the pace of development is adequate and that the development planned for different sectors of the economy are balanced and mutually consistent. The programming techniques discussed in subsequent chapters are intended to secure these ends.

1.6 The duration of plans

Generally speaking, there are three broad categories, in terms of duration, into which plans can be classified. These are, first, the so-called perspective plans, covering a span of two or three decades. These plans usually depict the general course to be taken by the national economy and indicate the more important structural changes. If the period covered is too long, however, the estimates may be vitiated by technological changes. The second category covers medium-term plans extending over, say, four, five or six years. The precise period is often determined by administrative and political requirements, but usually allows for the maturing of important projects. The duration selected is nevertheless sufficient to permit of detailed programming through the inclusion of specific projects. Sometimes, it may be useful to adopt a plan with a duration of about ten years. This may be enough to cover the full span of long-term projects as well as the period of a prolonged trade cycle. Finally, there are the short-term plans. Of these, the annual plans, as reflected in government budgets, are the most detailed and specific. Two-year or three-year plans of an operational nature are also possible.

It will generally be desirable for planning in a country to cover each of the main categories of plans described above. Detailed projects could thereby be built up within a suitable framework. The status of these

different kinds of plans will, of course, vary. Annual plans have the force of law, medium-term plans may be in the nature of commitments by governments, whilst perspective plans merely indicate broad horizons.

It is particularly important, in the case of the medium-term and long-term plans, to avoid inflexibility. Periodical—but not unduly frequent—revisions may well be needed. Such concepts as that of a “rolling plan”, which continuously maintains a perspective of a given duration are of relevance from this point of view.

1.7 Objectives and instruments of policy

Evidently, development plans have to be the expression of what are considered the objectives or aims of the country's economic policy. The objectives that are most commonly accepted are the following:

- (i) A rapid increase in *per capita* income,
- (ii) A high level of employment,
- (iii) A relatively stable price level,
- (iv) Equilibrium in the balance of payments,
- (v) A reduction of inequalities in income distribution,
- (vi) The avoidance of marked disparities in the prosperity and growth of different regions within a country,
- (vii) A diversified economy.

Although each of these objectives may be desirable in itself, there is the possibility of conflicts between them. It is, therefore, necessary to determine, in the light of the situation in each country, the objective or objectives to which precedence should be given in planning. Thus a country facing a rapid expansion in the workforce may wish to design its planning primarily in terms of the employment objective. The other objectives will then constitute “side” conditions, to be realized as far as possible in the course of pursuing the main objective. Sometimes different “valuations” may be given to the various objectives or aims (cf. chapters IV and V).

In a general way it may be said, however, that the objective of a rapid rise in *per capita* income should always be given high priority for the simple reason that the source of all material well-being is the availability of goods.

The objectives of economic policy may be achieved through several instruments. In many countries of the region, government investment itself constitutes the main instrument for attaining such objectives as higher incomes and greater employment. But stable prices and equilibrium in the balance of payments may involve fiscal and wage policies, whilst goals relating to income distribution may require measures of taxation. All these and other instruments will have to be used together in pursuing the objectives of economic policy. The choice between them and the extent to which they would be applied have to be determined in the course of preparing a comprehensive plan. It is, therefore, desirable at an early stage to distinguish between the several instruments that are available to a country and the particular objective which each instrument is best suited to serve. The problem of designing a country's economic policy is not solved by the mere indication of the aims but has also to consist of a choice of the set of instruments to be used in their pursuance.

Chapter II

PLANNING THE GENERAL RATE OF DEVELOPMENT

2.1 Introductory

The first step in development programming should be to determine the general rate of economic development which a country seeks to attain. As the most common and appropriate measures of economic development are expressed in terms of such aggregate quantities as national income, consumption, savings, investment or employment, the general rate of development may be most usefully set out in these terms as a set of economic targets for the country to provide a framework for the further stages in programming.

2.2 Shortage of capital

The general rate of development is always limited by shortage of productive factors. If any one scarce factor associated with under-development should be singled out, it would be capital. The final goal of development programming is, therefore, to find the best way of breaking the vicious circle between capital shortage and under-development and to design the most efficient and optimum rate of capital accumulation.

It would be an over-simplification, of course, to regard economic development as a matter of capital accumulation alone. Other things are needed in addition, such as entrepreneurship and training of workers and public administrators. Yet these are seldom possible without some increase in the stock of capital. Therefore capital accumulation may very well be regarded as the core process by which all other aspects of growth are made possible.

Capital increases by investment, and more investment necessitates more savings or foreign assistance. Foreign assistance, if not in the form of grants, means some burden in the future. The extent to which foreign loans can be serviced and repaid will ultimately depend on what can be saved at home in the future. Domestic savings are, therefore, the more reliable source of investment to break the vicious circle of poverty and under-development. But domestic savings can be increased only by a sacrifice in consumption which has to be compared with the future increases

in consumption it promises. Investment, moreover, yields different results, depending on the industries in which it is made. In order, therefore, for the government of an underdeveloped country to design an appropriate plan for development, it must be informed of the quantitative aspects of savings and investment, and their effects on production and consumption.

2.3 The desired pace of development

These quantitative aspects are of crucial importance in determining the most desirable rate of development. It is important, for one thing, particularly when population is growing rapidly, to estimate the rate of development that would be needed to bring about an improvement in *per capita* income or a high rate of employment for the growing work force. Another element which may play a role in estimating a minimum rate of development is the necessity to give a certain minimum size to some projects in order that they are at all economically sound. In some industries where so-called "indivisibilities" play a role, there are such minimum sizes of projects. For the country as a whole, this may mean that only a "big push", as it has been called, can really help to start the process of development. Although this may produce results which appear ambitious in the light of current efforts, it provides a fair indication of the tasks involved in the planning effort.

Whatever the initial approach, there are some useful concepts which should be borne in mind in planning the rate of development. These concepts may conveniently be described in terms of investment. There is, first, the concept of a *minimum rate of investment*, which measures the rate needed to prevent *per capita* income from falling in the face of population growth. A rate of investment somewhat above this minimum is the lowest target at which any plan should aim, even though this may involve a heavy effort when population is growing rapidly. For some countries this may be a rate that can be easily attained on the basis of an effort which does not require any fundamental policy decisions, any changes in attitudes or behaviour patterns, or any improvements in techniques, skills and methods of business or public administration. For these countries, the minimum rate of investment is clearly too low, and is useful only for reference.

A second concept of use in this context is that of a *practical maximum rate of investment*. In theory a maximum rate of investment may refer to a level of capital accumulation which involves saving and investing at least all income above, say, a subsistence level. Clearly, such a maximum is of no practical significance. A practicable maximum may, therefore, be determined differently in the light of the extent to which the population

would be willing to accept austerity now, so as to enjoy a higher standard of living in the future. The planner must form his best judgement as to what this practical maximum would be. The rate just defined above is the one to be determined by an evaluation of people's potential propensity to save.

A third concept is that of the highest rate of investment consistent with *absorptive capacity*. Absorptive capacity depends on natural resources, taxes, the labour supply, the level of labour, technical and managerial skills, entrepreneurial capacity, the efficiency of public administration, the extent of "technology-mindedness" of the population, and so on. Such capacity sets a limit to the amount of efficient investment physically possible, and although it can itself be increased through further investment, it does effectively limit the rate of development possible, particularly in the short run. Maximum absorptive capacity may, of course, permit of a higher rate of investment than that allowed by the ability of the population to save. In this case, it would be the role of an ideal international policy to fill the gap and to raise investment to the highest level consistent with absorptive capacity. On the other hand, where absorptive capacity is below the practicable rate of savings, both national and international policies should be directed towards raising such capacity. These policies would then constitute the initial phase of a long-term plan.

2.4 The current rate of saving

Thus, one of the logical ways to start planning the general rate of economic development is first to estimate the amount of domestic savings and capital imports that could be expected with no change in economic policies; then to calculate the rate of growth that this level of savings and investment would provide; and finally to compare it with the desired rate of growth. Usually, the ratio of saving to income is fairly stable over long periods of time, and these saving-income ratios are lower in under-developed countries (under 10 per cent) than in higher advanced countries (about 15 per cent). Any empirical estimation of this ratio must start with the observation of the rates of savings experienced by the country in the recent past. The estimates may be based on data for incomes and the savings of households, business and government, or domestic investment *minus* capital imports. It may also be possible to base the estimates on the experiences of comparable countries, keeping in mind the differences in income levels.

2.5 Capital-output ratios

After estimating the current rate of savings, the crucial question will be what amount of net national output may be expected from the investment

to be made on the basis of the estimated savings. A number of studies have been made on the amount of capital required to increase output by one unit per annum in each sector of economy and for a national economy as a whole. This amount is called the "capital-output ratio", or "capital coefficient".

Available data clearly show that for a number of countries, e.g. the Federal Republic of Germany, Japan, Norway, the United Kingdom and the United States, the capital-output ratio for a national economy as a whole remains stable over somewhat longer periods at a level of 3 to 4. This fact may well be explained by complementarities of industrial activities, or it may be that the increases in the capital-output ratios in some manufacturing industries are compensated by decreases elsewhere, possibly by external economies due to better transport or organization of the economy. Even though there are variations, it is perhaps one of the most useful parameters with a fair degree of stability. For post-war years the coefficient was found to be 2.6 for Ceylon, 2.3 for India, 4.7 for Japan, 2.3 for Malaya, etc. A better use of already existing idle capacity may have been responsible for the low values found for Ceylon, India and Malaya. These values can be expected somewhat to rise in the future. Since, moreover, the capital coefficients differ so much from one industry to another, and, in some cases, from one technique to another, it is conceivable that capital-output ratios will change in the future, depending upon the industrial structure of the economy and on the techniques to be chosen. Nevertheless, fairly reliable estimates of capital-output ratio can be made for most countries.¹ If exact estimates are difficult, the maximum and minimum values of possible estimates may be taken, and some alternative rates of development calculated.

This capital-output ratio may be considered, at this stage of our programming, as a tentative figure, and may be adjusted later as improved information, based on detailed sectoral studies, becomes available.

Although the capital-output ratio is usually calculated as the "average" capital-output ratio, what really matters is the "marginal" or "incremental" capital-output ratio: we need information on the capital required to *increase* the national output. If we want to increase output by 20 and estimate the capital-output ratio as 4, then the required addition to the capital stock, to be provided by new investment, is 80. Evidently the figure 4 in this example stands for the "incremental capital-output ratio".

¹ One may wonder if it is safe to assume that national output is proportional to (or a linear function of) capital only. In general, national output would be technically related to the employment of labour and capital, and this relation would change through time. To base the projection of national output mainly on the capital-output ratio implies a certain type of technical change in the relevant future. There are some other econometric models, such as the Douglas function, which may be usefully applied to some countries. Details of this type of possible formulations are omitted from the text here.

2.6 The projected rate of economic growth

Given estimates of the current rate of savings and the capital-output ratio, the rate of economic growth, in terms of national output, could be projected in the following way. If the current level of national output is 1,000, and the saving ratio is 0.06, domestic savings would be 60, which may be invested to generate the increased national output. With a capital-output ratio of 4, this amount of savings and investment could generate an increase in national output of 15, not more. An increase in national output of, say, 20 will not be possible, because the amount of investment required for this purpose is 80, which exceeds the current savings of 60. Hence, the increase in output warranted by the savings of 60 is $60 \div 4 = 15$, which gives the growth rate of 1.5 per cent in national output. The rate of growth in national output, can, thus, be calculated by dividing the saving ratio by the capital-output ratio.

National output (1)	Saving ratio (2)	Saving (3)	Investment (4)	Capital- output ratio (5)	Increase in national output (6)
1,000	0.06	60	= 60	4	15
Growth rate (G) = $\frac{(6)}{(1)} = \frac{15}{1,000} = \frac{(2)}{(5)} = \frac{0.06}{4} = 0.015$					

This method of projecting the future level of national output can be checked by other ways of forecasting, e.g. extrapolation of past figures. If the projected national income shows a lower growth rate than actual income did in the past, it may be that the saving ratio has been underestimated or the capital-output ratio overestimated. If the ratios are right, a slowing down of economic growth must be expected. Another check would be to divide the projected national output by the numbers in the active labour force, to obtain an index of the average productivity of labour in the future. If this index does not rise as much as the past trend, the estimates of parameters should again be reconsidered. If they are correct, inefficiency or unemployment must be expected in the future, unless measures are taken to prevent them.

The rate of growth of an economy will be somewhat less than shown by the preceding calculations, if the gestation period of the investment envisaged is large. The calculation above tacitly assumes that capital created by the investment in one period can be used productively in the following period. If, however, the gestation period of some investment project is longer than one year, say three years, then capital available for productive use will not increase before three years. At that time, the level of national income will be higher, and hence the rise in production,

as a percentage of total national income, is somewhat less. This means that the extension of the gestation period has the same effect as the decline in the saving ratio, or the increase in the value of the capital-output ratio. If this is the case, then the rate of economic growth computed in the preceding way must be adjusted downward. Needless to say, a lengthening of this time lag has further adverse effects, owing to the additional postponement of the fruits of investment.

2.7 Target setting

If such projections of current trends show no significant rise in the people's standard of living, there is a definite need to increase the growth rate of national output. Suppose that the expected population increase is 1.5 per cent a year, the saving ratio 6 per cent, and the capital-output ratio 4. This will leave the standard of living unchanged, and represents the minimum rate of investment as defined in section 2.3. If the *per capita* national income must increase by, say, 2 per cent a year, the national income must increase by $1.5 + 2.0 = 3.5$ per cent every year. This means that, with the same capital-output ratio, the savings ratio must be increased from 0.06 to 0.14, requiring a considerable adjustment in policy measures. If such a sudden rise in the saving ratio is difficult to achieve, the targets for improvements in living standard must be lowered to what was called, in section 2.3, the practical maximum rate of investment.

In some countries, the problem of unemployment may be so serious that targets must be set primarily in terms of employment creation. Suppose that the active labour force is expected to increase by 1.5 per cent per year, and that the increased labour force must be employed in productive activities. In order to know what increase in national output is needed to employ these workers, one has to know the trend of labour productivity. If, for instance, labour productivity increases by 2 per cent a year, then the growth rate of national output needed to employ all the increased labour force is calculated as $1.5 + 2.0 = 3.5$ per cent a year.

These two ways of setting the target for development programming may not result in the same rate of growth, because the growth rate of total population need not coincide with that of the labour force, and there is no reason why the requirement for the increase in the standard of living should be exactly equal to the expected increase in labour productivity. It is, however, of some importance to realize that setting a target in one way necessarily has an implication with regard to the quantities involved in another way. If the growth rates are the same for total population and labour force, the 2 per cent increase in the standard of living necessarily implies a corresponding rise in labour productivity.

2.8 Policies to increase the growth rate of national output

A target set in this way has an implication for investment. Since it is the investment warranted by savings that generates the increased national output, the increased savings must find an outlet in investment opportunities. The level of actual investment may not necessarily rise to the level which savings warrant, and the industrial distribution of investment is not necessarily such as needed to increase the productive capacities in the desirable direction. Here the problem of ascertaining the absorptive capacity, as set out in section 2.3, comes in. The problem of finding the optimal direction of investment will be discussed in the following chapters. Apart from this point, the increase in the growth rate of national output can be attained by increasing the saving ratio or by decreasing the capital-output ratio or by both.

There are three forms of domestic savings: (1) personal savings, (2) business savings, (3) government savings. If the current propensity to save on the part of the private sector proves insufficient to finance the required rate of investment, then the government must raise tax rates and try to save more than the private sector would do when left alone. Since this means less disposable income, there will be more or less strong resistance from the private sector. If voluntary savings plus taxes cannot finance the required rate of investment, the government must either try to obtain foreign assistance or lower the target. If neither alternative is possible, voluntary savings can be supplemented by forced savings, i.e. inflationary deficit financing, to which many under-developed countries have had recourse in the past.

Since, however, it will be easier to limit consumption in the private sector as the level of income, and hence the absolute level of consumption, rises, it is advisable for a national economy to save less in the beginning and more in the later years of the planning period. This implies that the growth rate of national output will rise from year to year. On the other hand, it may be possible for the government to persuade the public to save more now by promising more consumption in the future. Thus the time pattern of growth rate and saving ratio must be carefully examined.

As for the chances of reducing the capital-output ratio of a national economy as a whole, generalizations are difficult. So far as the direct effect is concerned, it is obvious that introduction of new techniques which require less capital to produce the same amount of output is desirable, and that the choice of product-mix may be made so as to require as little capital as possible. But there are many complex complementarities among inputs and outputs, so that the general effect is not very easy to ascertain. The adoption of technologies developed in labour-scarce countries

may tend to raise, rather than lower, the general capital-output ratio. If there is only a small margin of possible adjustment in technology, this result may be inevitable. However, there are other industries or technologies for which the capital coefficient can be adapted more easily, and the government may plan to emphasize those lines of production and techniques which will minimize the rise in the capital-output ratio.

2.9 Foreign assistance and trade

If the required rate of investment cannot be financed by domestic savings, and if the downward adjustment of the target is not desirable for one reason or another, foreign assistance is the only way left. Foreign grants or loans make it possible to import the investment goods needed for domestic investment without, at least, immediate payment in the form of exports. If the foreign assistance amounts to, say, 4 per cent of the national output, the requirement for the change in the saving ratio is decreased from 14 per cent to 10 per cent. It is worth remembering, however, that foreign loans must be repaid out of domestic savings in the future. Unless the increases in national output and the savings ratio guarantee the repayment of the loans, the foreign loans may become burdensome in the future. It is desirable, therefore, that the foreign loans are utilized to promote investment directly or indirectly, and to generate the increase in national output. With foreign grants, the problem of repayment does not arise. If a programme of development in the receiving country is dependent upon the inflow of foreign aid over a number of years, it is desirable to have prior assurance of such assistance for the necessary period.

A country which depends on foreign trade must export enough to cover its required imports. An unfavourable balance of payments and insufficient access to foreign loans certainly requires the curtailment of imports. This may limit the possible rate of investment, unless restrictions are imposed on the imports of consumption goods and these are supplied by the expansion of domestic production. The restriction of raw material and capital equipment imports will certainly hamper the pace of economic development.

2.10 Public and private sectors

A discussion of economic policies requires a clear understanding of the demarcation between the public and the private sectors. The relative importance to be attached to these two sectors is a matter to be decided by the persons or governments concerned, because it depends greatly on

ideologies and political considerations. The present discussion, therefore, is confined to an analysis of relationships between public and private investment, which is relevant to the rate of growth.

In most countries of this region, the private sector is much larger than the public sector. No comprehensive development programme, therefore, can ignore the private sector. But the control which a government exercises over consumption and investment decisions is much less in the private sector than in the public sector. For example, the investment decisions of the government are usually given legal status through the budget at least for one year, or, in some countries, for more than one year. In this case the government not only selects the projects but also carries them out. On the other hand, the government's activities in the private sector are limited to two steps: (1) projecting private consumption and investment and (2) if the projection does not conform to goals, trying to influence them by monetary, fiscal, foreign exchange and commercial policies, or consultation and direct controls. The mere announcement of the plan may affect the level and pattern of private activities. For these purposes, it is important to know the behaviour patterns of private consumption and investment, and the effects of different policies on them.

When a government has made its political decisions, regarding the relative size of the public and private investments and ownership of capital, the economic plan, designed by the methods discussed above, may not result in the desired division of investment activities and capital ownership. In this case, either the political goal of such a general division must be revised, or some economic activities transferred from one sector to the other. Which type of adjustment is chosen depends on whether the political goal or the more purely economic goal of development is given priority. In the former case, it is likely that such a plan will involve some cost in terms of income growth, which may perhaps be estimated and should be clearly understood. In the latter case, the answer will depend on available entrepreneurship, management, labour skills, and the expected rate of technological advance in the two sectors.

There is always a danger that simple programming of the kind discussed in this chapter may neglect the favourable impact of some kinds of public investment on private investment. The public and private sectors are complementary as well as competitive. First, investment in social overhead capital such as transport facilities, irrigation systems, land reclamation, power stations and housing may create private investment opportunities previously lacking. For one thing, the external economies of a good many projects of this kind are likely to exceed the direct benefits. In some cases, indirect effects will have to be considered while direct returns

will be too low to make the project attractive to private enterprise. It is much simpler for the government to execute such projects itself than to reorganize the market so as to permit private entrepreneurs to translate some of the external economies into direct profits. The Italian ten-year economic plan, for example, calls the aggregate of such projects the "impulse sector", and relies heavily on this type of investment. Secondly, the government might be able to accelerate the pace of technological progress and resource discovery more efficiently than individual private industries could, and thereby encourage increased long-run investment through geological surveys, research, new transport facilities to open up new areas, and the like. Thirdly, "human investment" in training managers, entrepreneurs, public administrators, and technicians might result in a higher level of autonomous investment with a given rate of resource discovery, technological progress, etc. In some countries, improved security might also have this effect. Fourthly, if the government succeeds in launching a process of sustained growth, profit opportunities will be created which will induce increased short-run investment.²

Within the limits for total investment, and if growth of *per capita* income is the chief aim of development policy, it could be stated, as a general principle, that public investment should always be expanded at least to the point where opportunities for private investment are maximized.

In most countries, it would probably be desirable to expand the public sector beyond this point after taking into consideration the points listed above. These factors are, of course, not easy to measure, but some estimate of their relative magnitudes can nevertheless be made. International comparisons can also provide some guidance as to the desirable division of resources between the public and private sectors. For most countries in the region, the relative size of the public sector is smaller than in such advanced "capitalist" countries as Canada and the United States. For these countries, it is possible to state with some assurance that expansion of the relative size of the public sector would accelerate the rate of growth.

2.11 Data needed

The data needed to plan the general rate of growth are those on national income, savings, investment, exports, imports, capital coefficients, population (including age structure, if possible) over a period of several

² Government policy may also reduce the incremental capital-output ratio in both the public and private sectors, so as to secure a greater increase in output at a given volume of investment. Training managers, skilled workers, public administrators, undertaking research leading to improvement of the product-mix or to capital-saving innovations — or inducing private enterprise to do these things — may have this effect. These aspects of development programming are dealt with in more detail in chapter VIII.

years in the recent past. Earlier data for the same country, and the data of comparable countries, will also be helpful. There are a number of studies available about international comparisons of such figures. National income or related aggregates may be estimated with the aid of partial data (industrial and agricultural production, exports and imports). In the absence of any figures, one could still obtain some indication on them from a study of comparable countries and careful observations of earlier data for more advanced countries.

Chapter III

PLANNING THE DEVELOPMENT OF THE MAIN SECTORS

3.1 Introductory

In most countries, more can be done in the field of planning than merely establishing the general rate of development as indicated in chapter II. Economic development implies structural change, due to the different rates of growth in various industries. Accordingly, it is extremely important to distinguish the broad sectors of the economy and to plan the appropriate rates of development in those different sectors. For example, at the core of under-development is usually a very slow expansion of demand for agricultural products combined with low man-year productivity in agriculture; hence the rise of national income must imply a shift of resources from agriculture to industry, which tends to expand faster. There are some cases in which the general rate of expansion is limited by barriers to the increase of production in particular sectors of the economy. Consequently, the models for planning the development of main sectors must be based on a differentiation of sectors, and the aggregate data broken down among major sectors. As long as the number of sectors remains small, relatively simple techniques can be used, and they are likely to be well within the capacities of most planning agencies. This chapter discusses the main points of handling some such sectoral models.

The value of planning schemes with a restricted number of sectors lies in the determination of the main conditions for "balanced" growth,³ which governments must take into account in designing policies. Such schemes, however, remain only approximations of reality. If they are to be as realistic as possible, they must be based on a considerable amount of "partial" research, i.e. research on details which precedes the composition of the scheme. We have here an example of "planning in stages", discussed above, which avoids the tremendous difficulties of taking account of all interrelationships simultaneously. From the purely scientific point of view, however, the method is second best. Countries already able to use the more sophisticated methods outlined later in this report should certainly do so.

³ "Balance" does not mean that all sectors or industries grow at the same rate, but that their rates of growth are in proper relationship to each other.

In succeeding sections of this chapter the procedure for composing such sectoral plans will be elaborated. It is assumed that a qualitative exploration of the present and future structure of the economy has been carried out in accordance with the discussion in chapter I. The choice between various alternative models depends a great deal on the planner's intuition and knowledge in this qualitative exploration. This first choice must be re-examined, however, at a later stage of the planning process, in the light of quantitative information. The models to be considered in the planning process do not have to be limited in number. Plural models may be used to investigate the different aspects of a national economy. The models presented below are not by any means exhaustive, but provide some examples which may be used for such investigation.

3.2 General conditions to be fulfilled by a "main sectors model"

Before proceeding to the discussion of a few concrete models, it will be useful to set out some general conditions which must be fulfilled by any plan of this type. These conditions are:

(1) The model should be *complete*. The sectors in the model, taken together, must cover the whole economy. For example, if a model consists of two sectors, a sub-division of the economy into agriculture and manufacturing industry is not complete. Such economic activities as trade, transport, etc. must be included somewhere in the model. Grouping those activities all together as "non-agriculture", a complete model would consist of "agriculture" and "non-agriculture".

(2) The model should be *realistic*. It should represent the more important relationships rather than less important ones. For example, in estimating future demand, it is unrealistic to concentrate on price elasticity of demand while neglecting income elasticity which is often more important for the general development of an economy.

(3) The model should be internally *consistent*. It should not assume, for one thing, that consumption is greater than resources permit. There are many, simple as well as complex, conditions to test the consistency of models. Since however, some of the conditions are of a technical nature, it is desirable to employ such specialists as theoretical economists, mathematicians, or econometrists and assure the fulfilment of these conditions.

3.3 Consumption-goods versus investment-goods sectors

Let us consider some of the main sector models which seem to depict the characteristic problems of under-developed economies. In determining

the general rate of development, the planning authority has already decided the division of increasing total demand between consumption and investment. This requirement on the demand side is not necessarily matched by the supply side. Since the growth of an economy depends on realized investment, it is highly desirable to pay closer attention to the supply of investment and consumption goods. Thus the natural and simplest division of the economy into two sectors is that between consumption and investment goods sectors. This division does not split the economy into two completely separated sectors. Both sectors purchase not only the investment goods from the investment goods sector, but also the raw materials for current production from each other. In the following argument, however, these intersectoral transactions will be ignored. This would not mean too much abstraction from reality if the economy has only a few industries to produce investment goods.

If the intersectoral current input-output relations are neglected, the sum of the net outputs of both sectors must equal national income. Given the consumption-income ratio, the supply of consumption goods must be equal to what is spent on consumption out of the national income. This implies that the production in two sectors must maintain a definite proportion to each other set by the consumption-income ratio. If the consumption-income ratio is 0.8, then the relative ratio of the net output of the consumption goods sector to that of the investment goods sector must be kept as 4 to 1. So long as the consumption-income ratio does not change, the two sectors must grow at the same rate. If, however, the consumption-income ratio (or the saving-income ratio) becomes smaller (or larger) as income goes up, then production in the investment goods sector must become greater relative to that in the consumption goods sector.

There is another important problem to consider in setting forth an economic plan in this two-sector model. That is how to divide the investment goods into the two sectors. Given the desired rate of income growth and the consumption-income ratio, the demand for consumption goods in each period will be determined. If this level tends to exceed the existing productive capacity of the consumption goods sector, then the shortage of productive capacity must be resolved by new investment in that sector. The required amount of new investment will be determined by the capital-output ratio of the sector multiplied by the required rate of increase in productive capacity. The goods for this new investment must be supplied by the investment goods sector. If, for instance, the capacity of the consumption goods sector is 800, and it is to be increased by 5 per cent a year, and furthermore, the capital-output ratio is 3.5, then the additional investment goods demanded by this sector is $40 \times 3.5 = 140$. The current productive capacity of the investment goods sector must certainly exceed this amount. Suppose that the maximum capacity

of the sector is 200. Then the excess capacity of 60 can be used to increase the productive capacity of investment goods sector itself. Given the capital-output ratio of this sector, say, 6, this excess capacity divided by 6 gives an increase of capacity in the investment goods sector of 10. Thus it is clear that if the capital-output ratios of the two sectors, the rate of increase in income and the initial levels of productive capacity are given, then they are enough to determine the distribution of investment goods between the two sectors.

In fact, however, the rate of increase in income can be determined within the system, as described in chapter II. The general rate of development is computed as the saving-income ratio divided by the capital-output ratio for the whole economy. Since, in this two-sector model, the productive activities of the consumption to the investment goods sectors always keep the ratio 0.8 to 0.2 (or 4 to 1) and their capital-output ratios are 3.5 and 6, the average capital-output ratio of the entire economy may be calculated as a weighted average: $(3.5 \times 0.8) + (6 \times 0.2) = 4$. Hence, the saving-income ratio being 0.2, the rate of growth in income, which is the same as the growth rate of production of both sectors, is $0.2 \div 4 = 0.05$, which is exactly the rate of increase in both sectors' production assumed in the above-mentioned examples. Any economic plan must be quantitatively consistent as illustrated by the numerical example presented in the tabular form below:

FOR THE FIRST YEAR

From \ To	Consumption	Investment		Total prod.
		Cons. G. Sect.	Inv. G. Sect.	
Consumption goods sector	$0.8 \times 1,000 = 800$			800
Investment goods sector		$3.5 \times 40 = 140$	$6 \times 10 = 60$	200
Income payment . .	800	200		1,000

FOR THE SECOND YEAR

From \ To	Consumption	Investment		Total prod.
		Cons. G. Sect.	Inv. G. Sect.	
Consumption goods sector	$0.8 \times 1,050 = 840$			840
Investment goods sector		$3.5 \times 42 = 147$	$6 \times 10.5 = 63$	210
Income payment . .	840	210		1,050

These tables can be extended to the succeeding years. So long as the consumption income ratio and the two sectors' capital-output ratios remain the same, the rate of development will be 5 per cent a year.

It may be justifiable, however, to raise the rate of development above 5 per cent by reducing the rate of consumption; for example, if the larger investment makes it possible for the investment goods industry to use better techniques or manufacture better machines; or if the planning authority can justify the reduction of current consumption, postponing any rise in consumption to a certain future period. In such cases, the planning authority must not only reduce the consumption-income ratio but also change accordingly the distribution of investment goods between two sectors.

Suppose that current consumption is planned so as to increase only at the annual rate of 2 per cent for the first two years, and the rate of consumption in the fourth year is to be raised as much as possible. Then a consistent plan for four years will look like the following:

FOR THE FIRST YEAR

To From	Consumption	Investment		Total prod.
		Cons. G. Sect.	Inv. G. Sect.	
Consumption goods sector	$0.8 \times 1,000 = 800$			800
Investment goods sector		$3.5 \times 16 = 56$	$6 \times 24 = 144$	200
Income payment . .	800	200		1,000

FOR THE SECOND YEAR

To From	Consumption	Investment		Total prod.
		Cons. G. Sect.	Inv. G. Sect.	
Consumption goods sector	$0.784 \times 1,040 = 816$			816
Investment goods sector		$3.5 \times 16.3 = 57$	$6 \times 27.8 = 167$	224
Income payment . .	816	224		1,040

FOR THE THIRD YEAR

To From	Consumption	Investment		Total prod.
		Cons. G. Sect.	Inv. G. Sect.	
Consumption goods sector	$0.767 \times 1,084.1 = 832.3$			832.3
Investment goods sector		$3.5 \times 71.9 = 251.8$		251.8
Income payment . .	832.3	251.8		1,084.1

FOR THE FOURTH YEAR

From	To	Consumption	Investment		Total prod.
			Cons. G. Sect.	Inv. G. Sect.	
Consumption good sector		$0.782 \times 1,156 = 904.2$			904.2
Investment goods sector			$3.5 \times 71.9 = 251.8$		251.8
Income payment . .		904.2	251.8		1,156

This plan makes it possible for consumption and income to make a sudden jump in the crucial year; namely, the rates of increase in income and consumption are 4.0, 4.2, 6.6 per cent and 2.0, 2.0, 8.6 per cent, instead of 5 per cent for both throughout the period. It is very important in the economic plan to keep consistent relationships between the supply of consumption goods and the investment needed to increase the productive capacity of the consumption goods sector.

In the above discussion, it has been assumed that the time lag between investment and output is uniformly one year, for both the consumption goods sector and the investment goods sector. In fact, however, in almost all instances, it takes more time to increase the productive capacity of the investment goods industry. This time lag—the period of gestation—has two important implications for planning. First, as investment is made in the investment goods sector, and wages and other payments are made, the money income in the hands of the public increases, without an increase, for some time, in the supply of consumers goods. This situation would tend to raise prices of consumption goods and lead to general inflation, upsetting the calculations on which plans are based. In these circumstances, the planning authority has the responsibility to tap the surplus income by taxation and borrowing. The scope and efficiency of these fiscal measures would then define a further limit to which the proportion of investment in the investment goods sector, in which the time lag is greater than in the consumption goods sector, can be increased.

Secondly, the time lag should be taken into account in deciding on the shape of the plan over time. If, for example, the planning authority aims at raising consumption in, say, 1962, and the necessary investment takes two years to show results, the investment should be planned for the year 1960. Moreover, the economic plan must carefully consider the time-shape of demand and supply of consumption goods and investment goods during and after the gestation period.

Finally, there is still a further issue for the planning authority to consider. The new industry for the manufacture of improved machines

may have to be established on a larger scale than the domestic market seems to warrant. In this case, it is advisable for the country to import the machines rather than produce them at home. On the other hand, planned development requires an assured supply of the key instruments of production, which fits in with the pace of development. If foreign trade or foreign aid cannot assure this supply, the planning country may decide to promote or establish the industry domestically.

3.4 Export versus home-market sectors

If foreign trade is a major economic activity of the economy, or if the limitations in export possibilities are one of important difficulties of the country, a two-sector model consisting of export versus home-market sectors may be useful. There may be some difficulty in dividing the economy into these two sectors, because the same industry may both export and sell in the domestic market. It will be assumed in the following argument, however, that the economy is split into two distinct sectors, specializing in export and domestic activities, and that the only intersectoral current transactions are purchases of new capital goods from the domestic-market sector by the export sector.

The obvious difference between these two sectors is that the growth of exports depends to a great extent on developments abroad, while the growth of home demand is primarily determined by domestic consumption and investment, and can be influenced by domestic economic policies.

Since exports are relatively more difficult to control, the best starting point for planning with this model is to estimate the probable rate of development of exports. Future exports depend primarily on the growth of foreign incomes and the income elasticity of the foreign demand for export commodities. On the basis of estimated foreign incomes or some other relevant variables, the future development of exports may be estimated at a given price level. In reality, however, there may be other factors which may interfere. Among these, foreign competition and foreign trade policy stand out. Foreign competition may take the form of price-cuts or supplying similar, but better, substitutes. The level of costs will, therefore, be very pertinent. For some products of the region, such as coconut products, fibres and rubber, the growing competition of synthetic products seems to be a restraint on expansion of exports. It may be useful to survey systematically the costs at which new export products could be added.

The export sector must develop at the same rate as the rate of development of demand for exports. The capital-output ratio of the export sector will then determine the demand for investment goods for this sector.

The home-market sector must supply not only these capital goods, but also meet its own investment-goods requirements and the demand for consumption goods, the demand for which depends on the incomes earned in both sectors. Part of home demand (domestic consumption *plus* domestic investment) will be directed toward and satisfied by imported goods, whereas the remainder will have to be supplied by domestic production. Thus the demand for the products of the home-market sector *minus* imports must be equal to the supply of this sector. Imports will depend on the level of production in the home-market sector, unless they are the raw materials of export products which depend on the amount of exports.

It is important to notice here that while the growth rate of the export sector is completely determined by the growth rate of exports, that of the home-market sector is influenced not only by the growth rate of exports but also by some other factors. For instance, the lower the consumption-income ratio the larger the share of the home-market sector's output available for the expansion of its own productive capacity, after meeting the demand for consumption goods and for investment goods for the export sector. It is easy to see, therefore, that the lower the consumption-income ratio, the higher will be the rate of growth in the home-market. To clarify this point still further, it is useful to consider the following numerical example:

FOR THE FIRST YEAR

To From	Consumption	Investment		Exports	Imports	Total prod.
		H-M Sect.	Ex. Sect.			
Home-market sector	$0.8 \times 1.000 = 800$	$3.5 \times 40 = 140$	$6 \times 10 = 60$		$-(0.25 \times 800) = -200$	800
Export sector				200		200
Income payment		800 (H.M. sector)		200 (Export sector)		1,000

FOR THE SECOND YEAR

To From	Consumption	Investment		Exports	Imports	Total prod.
		H-M Sect.	Ex. Sect.			
Home-market sector	$0.8 \times 1.050 = 840$	$3.5 \times 42 = 147$	$6 \times 10.5 = 63$		$-(0.25 \times 840) = -210$	840
Export sector				210		210
Income payment		840 (H.M. sector)		210 (Export sector)		1,050

In this example, it is assumed that the consumption-income ratio is 0.8; the capital-output ratios of the home-market and export sectors are 3.5 and 6 respectively; and the ratio of imports to domestic production is 0.25. If, and only if, exports increase by 5 per cent a year, then everything else in the economy can expand at the same rate. This happens because only a rate of 5 per cent coincides with the own rate of growth of the economic system determined by the coefficients mentioned above. If, however, the growth rate of exports is different from 5 per cent in this case, some complications appear in making a consistent economic plan. Suppose that exports in the second year are expected to be 205. The increase of exports by 5 requires the investment of $6 \times 5 = 30$. Consumption and imports being the same, this makes it possible to invest 170 in the home-market sector. This investment will increase the capacity of the home-market sector by 48.6 in the second year. This will certainly give a higher rate of growth to the home-market sector than to the export sector. The materialization of this higher rate may be hampered by the shortage of imported goods, because the domestic production of 848.6 requires imports of 212.15, which exceeds exports by 7.15. Unless the unfavourable balance of trade is paid out of the accumulated foreign exchange reserves, import-replacing activities will have to be developed, to preserve the balance of payments equilibrium, and the higher rate of growth in the home-market sector. The choice of such import-replacing industries must depend on the size of the domestic market in comparison to the optimum size of the industry and on the prospective cost level with due regard to the usual "learning" in the process of development.

On the other hand, if exports increase by more than 5 per cent, say to 220 in the second year, the extra investment needed to produce the additional export commodities must be subtracted from the investment in the home-market sector. In this way, rapid development of the home-market sector may be limited by the need to curb home demand for the sake of a sufficient volume of exports. In the above numerical example, 10 extra exports require 60 more investment in the export sector, so that only 80 investment will be made in the home-market sector. The increase in capacity of the latter will therefore be $80 \div 3.5 = 23$. Hence, the rate of growth of the home-market sector will be less than 5 per cent. Thus it is clear that the growth rate of the home-market sector depends on the coefficients in the system. Since, however, exports exceed imports, even a higher rate of growth is possible with the home-market sector if the necessary investment goods are imported. If their capital-output ratio is the same, the imported investment goods will raise the capacity of the home-market sector by the amount of imports divided by the capital-output ratio. Thus it must be clear that three basic relations are involved in this model: the demands and supplies equated for both sectors, and the balance of payments.

There is scope for refining this model. The first and foremost refinement may be to introduce price levels for the two sectors. This brings a certain adaptability into the economic system. A larger volume of exports can be obtained, if need be, (because of employment, say,) by accepting a lower price for them. At the same time, it may be possible to increase national income by shifting between exports and home market production, depending on the relative values of the two capital coefficients. There are various ways of translating this adaptability into formal economic relationships, depending on the behaviour of citizens and the instruments of economic policy available. One very simple way of presentation consists of assuming free competition, a "classical expenditure pattern", and one instrument of policy, e.g. indirect taxes. There is a large number of their possibilities and it is hardly possible, in the context of this report, to attempt a systematic treatment. One general warning might be in order, namely, that many pitfalls beset the unwary development planner. The estimates of the various relations should at least have an *order* of magnitude which is well within the range of realistic values.

3.5 Farm versus industrial sectors

In most countries of the region, agriculture suffers from overcrowding, very low productivity and a very low standard of living. As the number of people in the rural areas is still increasing rapidly, it is often argued that the most overwhelming necessity of economic development comes from the need to find alternative employment for some of the people now engaged in peasant agriculture. Otherwise misery, hunger or even starvation will prevail.⁴ This is more than enough justification for a model consisting of Agriculture and Non-Agriculture Sectors or Farm versus Industrial Sectors.

Analysing the "dualistic" structure of under-developed economies, the literature uses different terms to describe the two sectors in a model of this sort: "advanced and retarded", "industrial and rural", "monetized and non-monetized". None of these divisions is strictly accurate; the two sectors are broadly distinguishable but could not be precisely demarcated from each other. Broadly speaking the advanced sector consists of plantation agriculture, mining (including petroleum), large-scale manufacturing, and the financial, transport, storing, and other services connected with these industries, while the retarded sector is made up of small-scale peasant

⁴ "Asia, with half the world's population and nearly two-thirds of the world's rural population, has only one-fifth of the world's agricultural land. More than two-thirds of Asia's manpower is engaged in providing its populations with a subsistence standard of living. A similarly high proportion of consumer incomes is spent on food alone, whose quantity and quality hardly meet even the minimum nutritional requirements", United Nations, *Economic Bulletin for Asia and the Far East*, Vol. VIII, No. 3 (November 1957), p. 26.

agriculture, handicrafts and very small-scale manufacturing, and the financial, transport, and other services related to these activities. The first sector tends to be capital-intensive, technologically advanced, efficiently managed, high-productivity, monetized, and often export-oriented. The second is labour-intensive, technologically retarded, low-productivity, and is, for the most part, oriented to the domestic market.⁵ For convenience, the terms farm versus industrial sectors will be used here, the imperfection of the terms being recognized.

Countries which now have high levels of *per capita* income have reached their present position by a double shift in the structure of employment; from agriculture to non-agriculture, and within the agricultural sector, from small-scale, labour-intensive peasant agriculture ("farming") to extensive, relatively mechanized, commercial agriculture ("industrial agriculture"). If absorption of labour into the non-agricultural sector exceeds the total growth of the labour force, these two shifts will take place together; but if land is very scarce and non-agricultural employment increases by less than the growth of the labour force, non-agriculture may grow relative to agriculture as a whole, and yet the shift from "farming" to "industrial agriculture" may not take place. In this case, economic development as a whole will be retarded by continued presence of small-scale, low-productivity farms.⁶

The industrial and farm sectors may have extremely limited inter-relationships. In many countries of the region, the farm sector is not a major market for the output of the industrial sector, nor does the industrial sector absorb a large portion of the output of the farm sector. Capital and entrepreneurship do not flow easily from one sector to the other; in this respect they resemble Cairnes's "non-competing groups".

⁵ "Under-developed countries have their specific employment structure, with most of their people in agriculture and few in industries, because this structure corresponds to the low levels of productivity and to the attitudes associated therewith. At low productivity levels, most of the population is engaged in feeding itself and producing the essential minimum of agricultural raw materials for clothing and housing, and also the agricultural export crops on which the satisfaction of basic import needs depends. Productivity being so low, very few people seem obviously surplus to the requirements of these basic tasks and available for the production of manufactured goods. Similarly, on the demand side, there is a low level of real incomes and a low demand for manufactured goods, and hence for workers in manufacturing. Thus, the low level of productivity and the non-industrialized employment structure form a low-level equilibrium in under-developed countries. A relentless increase of population, combined with a likelihood of diminishing returns in agriculture, is particularly instrumental in creating this trap, or "vicious circle" (United Nations, *Economic Bulletin for Asia and the Far East*, Vol. IX, No. 3 (December, 1958), p.6.)

⁶ In countries such as the Federation of Malaya, Indonesia and the Philippines there is a third sector—smallholders' production for export—which does not fit conveniently into either of the two main categories. In these countries there would be advantages in constructing plans in terms of three sectors instead of two; indeed, expansion of the smallholders' sector may constitute the bridge between the industrial and farming sector that would ultimately produce an integrated economy. If a two-sector model is to be used, however, smallholders' activities obviously belong in the agricultural sector and in the "farm" sector. In this section we shall confine ourselves to two-sector models.

There is, however, some mobility of labour between them. These characteristics must be taken into account in constructing the farm versus industrial sectors model.⁷

A convenient starting point for planning the development of farm and industrial sectors seems to take the increase of population in the agricultural sector of the country as given, and estimate requirements for absorbing population in the industrial sector. Every country in the region will presumably wish to increase the relative size of the industrial sector; some may wish to employ the entire population increase outside of agriculture. Indeed, where rural overcrowding is extreme, it may be necessary to aim at absolute reductions in the number of small farmers. In that case still more rapid growth of the industrial sector is required. This is the process which is implied in "industrialization". It is quite natural, therefore, that any effective development plan in this model must include long-run targets for an increase in the relative proportion of the labour force in industry. The crucial question is, then, what are the factors which limit the absorption of farmers into industrial production? One limiting factor may be agricultural production itself; unless more food and more raw materials are available for urban consumption and industrial production, it will not be possible for more people to live in the urban areas, for industrial production to increase, and for employment opportunities in the industrial sector to grow. But increased output of food and raw materials requires higher productivity per acre and per man in agriculture. Otherwise prices of food and raw materials will rise relatively to the prices of industrial products; profits and real incomes in the industrial sector will fall, depriving industrial production of its incentive to expand. Thus there is a limit to expansion of industry set by the possible increase in productivity in agriculture. It is important, therefore, in planning to keep the balance between the demand for and the supply of agricultural products.⁸

⁷ In most countries, statistics are much better for the industrial sector than for the farm sector. As we progress to more complex models, it will be desirable to break up the industrial sector into sub-sectors; but it may be expedient to continue treating the farm sector as a single unit, having what is in effect a "foreign trade" and "emigration" relation with the industrial sector.

⁸ The argument here is conducted in terms of a closed economy. If, however, industry can export its output to finance imports, then it is possible to supplement the insufficient supply of food and materials by imports. In this connexion the argument on the export versus home-market sector model is relevant. In order to increase exports and production, industry must expand its capacity, which requires investment. The amount of investment needed to increase capacity is determined by the capital-output ratio or the capital coefficient in industry already discussed in section 3.4. Without loans or grants from abroad, this industrial investment (and investment in agriculture) must be supported by the domestic savings mainly of the people in the industrial sector. If savings do not cover the total requirements for investment, then some restrictions must be imposed to cut down consumption. The higher the people's propensity for thrift is, the better the chance of economic development is. This supply of capital is another limiting factor to restrict the rate of industrial expansion.

In this model, the division of the economy into these two sectors should not be confined to the production side but also extend to the expenditure side of households, particularly because the behaviour patterns of the people in the two sectors are quite different. Then the supply of agricultural products must be equal to the demand from the industrial sector *plus* the reservation demand for the farm sector itself. This latter type of demand is sometimes very important.

In order to sustain industrialization, the industrial sector must produce more than necessary to satisfy the current consumption of both sectors and thereby increase the capacity of the economy. Since there seems to be considerable scope for increasing agricultural productivity per man-year,⁹ investment must be directed towards meeting requirements in the farm as well as industry sector. The optimum division will be reached if the productive capacities of both sectors are fully utilized, and the maximum amounts possible with consideration of capital-output ratios are invested in both sectors. If this amount of investment in the industrial sector does not increase the level of the sector's capacity sufficiently to absorb the number of workers set as a target, it may be necessary to reduce the rate of consumption or to lower the target.

In estimating the number of workers associated with a level of production in each sector, close attention must also be paid to the change in labour productivity.¹⁰ In order to make a plan in terms of the farm versus industrial sector model, therefore, it is important to have at least some ideas and data on the demand for food and raw materials and for industrial products, the capital coefficients of both sectors and the productivity of labour in each sector.

3.6 Three-sector models

The models above have been confined to two-sector models, and each one depicted on basic characteristics of the economy concerned. A natural step to come in development planning would be to combine these models and consider some fundamental problems at the same time. This leads to constructing three-sector models or four-sector models. However, so long as there is only one investment goods sector, the increase in the

⁹ Cf. United Nations, *Economic Bulletin for Asia and the Far East*. Vol. VIII, No. 3 (November 1957)

¹⁰ In this connexion, it may be pointed out that, in addition to the impact of investment on agricultural productivity, it is very important to take into account the influence of better technical knowledge, a change in attitude of labour and enterprise, etc. Industrialization implies radical changes in the social relations of people in the rural area. Problems of adaptation to an entirely new environment should be carefully examined in this connexion. These problems are being studied by the UNESCO Research Centre on the Social Implications of Industrialization in Southern Asia, Calcutta, India.

number of sectors does not warrant any substantial change in the planning process. For instance, a model consisting of the export sector, the consumption goods sector and the investment goods sector can be dealt with in almost the same way as any two-sector model. But if there are two or more sectors which produce investment goods, then an entirely new type of problem appears. This is essentially the problem of finding an optimum allocation of capital among different sectors, to be discussed in the following two chapters. It may be appropriate, however, to point out here how this problem comes out.

Suppose that the economy consists of two sectors, both of which produce investment goods as well as consumption goods. Given the level of income, the propensity to consume the goods produced by the two sectors, and the capacities of the two sectors, there is no reason to expect that the demands for the products of both sectors exactly coincide with the capacity levels of those sectors. Since the consumption pattern cannot be changed at random, at least one sector is likely to be at work within its capacity. This is true particularly when the pattern of consumption changes over time. Then the crucial question is how to achieve the maximum rate of development over a number of years, or in a certain future year, while avoiding excess capacity or overinvestment, using the limited amount of resources available, and keeping some balance equations such as the balance of payments equilibrium.

3.7 Data needed

In addition to the data needed for planning the general rate of growth, the two-sector models discussed in this chapter require the introduction, into the model, of statistics of output, income, and employment, price indices and wage rates, income and price elasticities of demand, and capital coefficients, as well as labour productivity for the main sectors.

Chapter IV

INTEGRATION OF A PROGRAMME OF PROJECTS INTO AN INVESTMENT PLAN

4.1 Introductory

The preceding chapters have dealt with some simple models for programming. The logical procedure would be to break up aggregate and sectoral plans into programmes and projects which would fill up this framework. In practice, however, the procedure is often the reverse. Departments of national and regional governments and private organizations approach the planning body with individual projects or groups of projects, and the latter has to scrutinize and appraise them, and incorporate them, if desirable, into sectoral and national plans.

4.2 Projects, programme, plan

For a clear treatment of the problems dealt with in this chapter some terms may first be defined. A *project* is the smallest unit of investment activity to be considered in the course of programming. It will, as a rule, be a technically coherent undertaking which has to be carried out by a private or public agency and which can be carried out, technically speaking, independently of other projects. Examples of projects are the building of a factory, the construction of a bridge or a road, the reclamation of a piece of land.

A *programme* is a co-ordinated set of projects. They will be located in the same country or in some smaller geographical unit (state, province, region, municipality). They will also be started in some specified period, which may be a year, a five-year span, or some other period. The degree of co-ordination in other respects may vary but the projects will have been considered by some authority with a view to co-ordinating them.

An *investment plan*, in this context, is something arrived at "from above", through calculations referring either to the whole economy or to certain sectors in certain areas. It is not constructed by combining projects, but derived from the broad development aims set.

One of the major problems of development policy consists in linking up programmes with plans. Historically, the activities of authorities in

the field of development consisted of approving and financing sets of projects to be carried out by public bodies. More and more the need has been felt to integrate such programmes into a plan; in fact, a plan cannot be simply a set of projects. This means that the size of the programmes in different sectors or areas should correspond to what a balanced plan would require. This already implies that projects which are complementary from a technical point of view are either jointly included or jointly excluded from a programme; to include only one of them obviously means waste. Thus, programmes in the field of energy and in the field of roads should both be geared to the desired or expected increase in general production in a region. This correspondence is not guaranteed in advance. On the one hand, the programmes may be too small or too large. On the other hand, the projects contributing most to the realization of the aims of development may not be included.

In order to establish the desirable correspondence, two things have to be done. First, the projects known to the authorities should be appraised. Secondly, the possibilities of designing new projects should be explored, and where desirable their realization should be promoted. These subjects will be taken up in order.

4.3 Direct and indirect effects of a project

For a proper appraisal of any project, the first thing to be done is to ascertain its impact. In theory the impact of a project includes the effects of its execution on all aspects of the government's development policy, namely, national income, national savings, employment, income distribution, social changes, cultural changes, public health, etc. In principle, the direct and indirect effects should be determined for all the aims of economic policy, since these are the things of interest to the community. In practice, only the more important effects can be considered, and these only insofar as they can be estimated.

Various imponderables must also be taken into account. In fact, they are almost always present and may sometimes be the most important effects of a project. But, being by definition not amenable to quantitative measurement, they must be a matter of subjective opinion or intuition. If they are therefore to be included as elements in programming, they should be assigned some estimated values; otherwise they cannot form part of the programming models which are worked out in quantitative terms.

For this reason, the quantitative methods of appraisal discussed below can never be the only basis for the decisions to be taken on the inclusion or exclusion of projects from a plan. These methods may, however, be of considerable help in decision-making, especially for projects whose

quantitative aspects are important. The final decision must always be taken by "wise men", able to appraise the combined quantitative and imponderable implications according to the aims of development policy.

The effects of a project may be divided into primary and secondary effects. The primary effects may, in turn, be divided into direct and indirect effects. With regard to the consequences for income, these subdivisions can be defined as follows: direct income increases are those within the sector of the project; indirect increases are those in sectors vertically connected with that sector, because of direct technological links; secondary effects are all other consequences.

Other subdivisions are conceivable, and the choice among them depends on the method of analysis used. Employment and savings effects may be ascertained along lines similar to those followed for income effects. With regard to other effects, other methods will sometimes have to be applied. Thus, the consequences of a medical project, resulting in a lowering of the death rate, may be an increase in the rate of population growth, calling for higher investment to achieve income targets.¹¹ Effects can also be subdivided into those felt during the period of construction (gestation) and those which occur after the project is in operation.

The most accurate method of estimating the economic impact of any programme would be to use a detailed econometric model bringing out all the relationships existing between the projects and the economy as a whole. Such models will be very complicated, and can be used in very few countries in the region at the present time. Something will be said about them in chapters V and VI, but for practical purposes, approximative methods must be recommended. These are discussed in section 4.10.

4.4 Valuation of the impact; concepts to be used

After the impact of a project or set of projects has been ascertained, the question of valuation arises. The purpose of valuation is to devise criteria for the selection of projects to be included in the plan. In other words, criteria to indicate priorities are needed.

A few methods may be briefly discussed here. It will be assumed that the general aims of the government's development policy are already known and have been expressed in terms of the development, over a number of years, of national income, employment, savings, income distribution, cultural and medical improvement, etc. These targets may have been

¹¹ Some kinds of public health improvements, such as elimination of debilitating diseases, may conceivably raise productivity more than population.

tentatively formulated for a number of sectors; production and employment, and perhaps savings, may have been estimated for several sectors. The desired cultural and medical changes are themselves sectoral targets.

It will be further assumed that the impact of each project on each of these phenomena has also been estimated. In order to fix ideas, let it be assumed that, for the planning period, the targets for the economy as a whole are:

- an increase "A" in national product
- an increase "B" in employment
- an increase "C" in savings
- an increase "D" in some health index, e.g. the increase in expectation of life or the decrease in infant mortality; etc.

Sometimes, it will be useful to distinguish the components of one target, such as the increase in national product, and to give separate weights to these components.

Any single project 1 will yield increases a_1, b_1, c_1, d_1 , etc. in these categories, a project 2: a_2, b_2, c_2, d_2 , etc. In order to appraise the projects, "valuations" must be given to the various targets, say, p to a unit increase in national product, q to a unit increase in employment, r to a unit increase in savings, s to a unit increase in the health index, and so on. To begin with, these valuations may be assumed to be intuitive estimates of the planner. The imponderable aspects have also to be valued intuitively; but, as already observed, these may be judged afterwards by the "wise men". The total "valuation" of project 1, say V_1 would then be equal to:

$$V_1 = a_1 p + b_1 q + c_1 r + d_1 s$$

that of project 2 would be:

$$V_2 = a_2 p + b_2 q + c_2 r + d_2 s, \text{ etc.}$$

On the cost side, a major factor will be the capital invested in each project, which may be called k_1, k_2 , etc. There may be other scarce factors on the cost side, such as foreign exchange f_1, f_2 , etc.

A numerical example may illustrate the points made. Let the targets for the economy as a whole be:

- A: the increase in national product: \$1,000 million;
- B: the increase in employment: 1 million persons;
- C: the increase in savings: \$400 million;
- D: the increase in life expectancy: 1 year.

For individual projects 1 and 2 the consequences may be estimated to be:

$a_1 = \$1 \text{ million}$	$a_2 = \$800,000$
$b_1 = 500 \text{ persons}$	$b_2 = 1000 \text{ persons}$
$c_1 = \$500,000$	$c_2 = \$100,000$
$d_1 = 0$	$d_2 = 0$

When an increase in income of \$1 million is considered of the same value as an increase in employment of 500 persons and as an increase in savings of \$0.2 million and an increase in life expectancy of 2 years, then the "valuation" of project 1 would be $V_1 = 1 + 1 + 2.5 = 4.5$ and that of project 2, $0.8 + 2 + 0.5 = 3.3$. Furthermore, the costs involved in both projects may be capital invested: $k_1 = \$2 \text{ million}$ and $k_2 = \$1.2 \text{ millions}$, and foreign exchange requirements: $f_1 = \$500,000$ and $f_2 = \$200,000$.

The use to be made of these various concepts may now be illustrated for a succession of examples, arranged in order of increasing complexity.

4.5 One aim (income increase) and one scarce factor

To begin with, let us assume that the government has a single aim: to increase income. Assume also that only one scarce factor is involved, and that a fixed quantity of capital is available for investment, i.e. that the total size of the programme has been determined on the basis of the considerations discussed in chapter II. The procedure to be followed now is to select projects on the basis of their "yield" (ratio of increase in national products to capital invested), $\frac{a_1}{k_1}$, $\frac{a_2}{k_2}$, etc. In our numerical example this would mean that the two projects quoted show "yields" $\frac{1}{2}$ and $\frac{0.8}{1.2}$ respectively. The project with the highest yield will be taken first, then the next highest, and so on, until the capital available is fully used. In this way, the maximum increase in income will be obtained from the given amount of investment. This method is similar to the one used by the private investor, who selects projects according to rates of

profit; however, for national planning increases in income accruing to the nation as a whole are taken instead of income accruing to the private investor alone.

The maximum contribution to national income so obtained may or may not coincide with the expectations of the plan. If the aggregate and sectoral plans have been based on correct figures for (marginal) capital coefficients, there will be no discrepancy; as a rule, however, some discrepancy, in one direction or the other, will be found, indicating the necessity of revising the original plan. Here is another example of "planning in stages".

If a plan subdivided into sectors is available, the same procedure may be followed for each sector. The procedure then supplies a check on the plan, since it may happen that the "last" project *accepted* in sector I may be less "advantageous", in terms of increase in national income, than the first project *excluded* from sector II. It would be better, then, to introduce the latter and reject the former; this revision represents an improvement of the plan. The decision should, however, depend on whether the assumptions underlying the plan seem better or worse, more or less realistic, than the calculation of effects of projects. Thus the plan may be a better guide to selection than the yield calculations, for those projects which are complementary to the growth of the economy as a whole or of certain sectors, such as energy and transport projects or technical schools.

4.6 Several aims and one scarce factor

When more than one aim is at the basis of development policy, use should be made of the "valuations" introduced in section 4.4. As already pointed out, these valuations may be chosen intuitively to begin with; they should reflect what, in the planner's mind, a unit increase in each target means to the nation. Evidently only the *relative* values of p , q , r , etc. matter; that is, " p " could be taken as equal to 1. Upon the choice made for q , r , etc. the various projects will have a valuation V_1 , V_2 , etc., and again those with the highest "yield", $\frac{V_1}{k_1}$, $\frac{V_2}{k_2}$, . . . , should be taken first, etc., until the capital available for investment has been wholly exhausted. Our numerical example shows values of these yields of, respectively $\frac{4.5}{2}$ and $\frac{3.3}{1.2}$ or 2.25 and 2.75, for projects 1 and 2.

The actual additions to national income, employment, savings etc. thus obtained may well be different from what the plan envisaged. If all of them are more favourable, so much the better. If some are better,

and others worse, e.g. employment, there is scope for a re-assessment of the valuations q , r , etc. A higher value should then be given to q , until a programme results in what corresponds more closely with the plan. Thus, by experimenting with the figures q , r , etc. the closest possible approximation to the various targets in the plan can be attained.

Thus, if the valuation system so far followed, with

$$p = q = r = s = \frac{1}{\$1 \text{ million}} = \frac{1}{500 \text{ persons}} = \frac{1}{\$200,000} = \frac{1}{2 \text{ years}}$$

for the objectives income, employment, savings and life expectancy, leads to a programme which would fulfil the income and the savings target, but not the employment target, it will be necessary to revise the valuation of employment upward. Suppose the valuation of employment is raised

to a level of $\frac{1.5}{500 \text{ persons}}$, then the new valuation figures for the two projects will become:

$$V_1 = 1 + 1.5 + 2.5 = 5 \quad \text{and} \quad V_2 = 0.8 + 3 + 0.5 = 4.3$$

Generally speaking, projects like No. 2, with relatively large contributions to employment, will increase more in valuation than will projects with relatively little contributions to employment, and as a consequence, the new programme will make a relatively larger contribution to employment. It depends on the figures whether the new programme will already be satisfactory. If not, the valuation of employment must be further raised.

It may be, however, that the plan itself has to be revised; it may prove impossible to attain the values A , B , C , etc. set forth in the plan. That is, the plan may have been based on unrealistic coefficients. On the other hand, it may be that the estimation of the contributions a , b , c , etc. has been erroneous, in which case the planner may decide accordingly not to change the plan, but to revise the calculations of the impact of the projects.

4.7 Several aims and several scarce factors

When not only capital but also other scarce factors e.g. foreign currency, natural resources or skilled labour, are used in the projects, the denominator of the yield figures should not be capital invested (k , k , etc.) alone, but the valuation of the factors of production. This means that valuations must then be introduced for factors of production as well as in the product market. For factors of production, these valuations are often called "accounting prices"; these are discussed in section 4.9. Again, starting from an arbitrary set of relative prices for factors, a programme

may be selected, but the quantities of factors to be used may deviate from those available. Here too, therefore, relative accounting prices may be found by trial and error, which result in a programme using the quantities available.

4.8 Distribution of the programme over time

The same techniques can be used to find the most appropriate distribution of projects over time. A time distribution enters the picture in two ways: the effect of each project is distributed over time; and the moments at which various projects are started can also be varied. For both purposes valuations may have to be differentiated with regard to time. The procedure is to assign a price q_1 , say, to employment to be created in year 1, a price q_2 for employment to be created in year 2, etc. The usual method is to "discount" future contributions to income or employment; but uniform discounts can lead to results inconsistent with the aims of development policy. Discounting of individual contributions may be avoided altogether if a plan exists, differentiated with regard to years (and sectors). The projects might then be chosen by trial and error so as to finally fill up the income and employment increases envisaged for each year. In general, however, accounting prices for different years constitute a more flexible and systematic instrument. The time element also comes in if the gestation period is very long; effects during the gestation period are quite different from those during the period of operation.¹²

4.9 Use and estimation of accounting or shadow prices

The valuation of a project may sometimes require splitting up its costs into its components. This need is especially clear if use is made of so-called accounting or shadow prices. Accounting prices are fictitious prices which may be assigned to some cost elements, or products, with a view to giving a better approximation of the relative importance of these elements or products to the economy. An example is costs to be paid in foreign currency, or proceeds in foreign currency. These may well be more important to the economy than the official exchange rate indicates. In a general way, accounting prices are the price levels at which there is equilibrium between demand and supply. At the official exchange rate there often is no equilibrium; foreign exchange is made available too cheaply and the demand for it therefore surpasses supply. Moreover, there are good reasons to believe that also the actual prices of labour and capital in under-developed countries are different from their

¹² The gestation period is discussed further in chapter V.

"intrinsic" value to the economy or equilibrium value. Unskilled labour in an under-developed country is so plentiful that supply surpasses demand. Concomitantly, the use of an additional unit of it does not deprive the country of much product, and therefore has a smaller value than the wage paid. Capital may well be more valuable to the country than the official interest rates indicate, as is illustrated by the much higher rates for private loans.

In a sense, accounting prices are also "valuations" as introduced in section 4.4, but they refer to such categories as production factors and products, rather than targets of economic policy.

The estimation of accounting prices can be undertaken along the lines suggested for the valuation of targets in section 4.6 and for factors in section 4.7, that is, by trying out a certain price and changing it until there is equilibrium between demand and supply of the factor concerned. Strictly speaking, this procedure is adequate only if the projects to be selected cover the investment activity of the economy as a whole. If, for example, accounting prices are assigned only to projects in the public sector of a country with a considerable private sector, the resulting programme may be far short of the optimum. In such cases, the accounting prices should, in principle, be based on the total effects on investment, including induced private investment. It may then be necessary to use more advanced methods, intended to cover these effects as well. Theoretically, the best solution is to have a multi-sector model of the types to be discussed in the next chapter.¹³

Accounting prices can sometimes be based on independent econometric models of a simpler type, as in the case of accounting prices for foreign currency. With the aid of the price elasticities of demand for imports and exports and some other coefficients, an estimate can sometimes be made of the exchange rate which would equilibrate the balance of payments.

4.10 Approximative methods of appraisal

The calculations discussed in the preceding sections will often be much too complicated to be carried out with all precision that could theoretically be claimed. In practice, therefore, there is a need for approximative methods in all phases. Such methods are discussed briefly below.

¹³ Cf. Hollis B. Chenery, "Development Policies and Programmes", *Economic Bulletin for Latin America*, III (1958), p. 51 ff.

They will already have to be used in the first phase of the appraisal, namely for the estimation of the effects of projects. Thus the estimation of the contribution to national income any project makes will often consist of a fairly precise calculation of the direct contribution. This consists, in principle, of assessing the gross product and the costs of operation; details concerning these calculations can be found elsewhere.¹⁴ The indirect consequences can be assessed by asking the question, "What additions to national income will occur in the industries (i) supplying inputs of raw materials and capital goods to the project and (ii) processing the products to be expected from the project?" Sometimes the answer to this question is far from unambiguous. Guidance may be obtained from a careful analysis of what can be expected, in these industries, to be the pure consequences of the project, and what changes in those industries cannot really be attributed to it.¹⁵

The secondary effects, finally, can be estimated by applying Keynesian multipliers to the various categories of additional income to be created by the project; thus different multipliers may be applied for farm incomes, labour incomes and the remaining group of incomes, based on assumptions about taxes, savings and the import content of the expenditures of these three groups. Secondary effects on output and employment are only to be expected, however, if there are unused factors and the complementary factors needed for production.¹⁶

In the second phase, that of valuation, approximative methods can also be devised. In the absence of precise estimates of valuations, the method of filling up the planned figures in the various sectors already mentioned above may be of help. Valuations may also be obtained by interviewing persons acquainted with the views of the government concerning the various aims of their policy. Discounts of future income may be undertaken with the interest rates prevailing in the capital market for loans of different maturity. To the extent, however, that the planner adheres to the theory that market prices of labour, capital and foreign currency deviate from accounting or shadow prices, the latter may simply be set at some reasonable levels. Thus, an accounting wage of 50 per cent of market wages and an accounting interest rate of 200 per cent of market rates for commercial loans may reflect the relative scarcities of capital and labour more accurately than the market prices themselves.

¹⁴ United Nations Economic Commission for Latin America, *Manual for Economic Development Projects*, (E/CN.12/426).

¹⁵ A concrete example will be found in J. Tinbergen, *The Design of Development*, (Baltimore, 1958), p.33.

¹⁶ The mere presence of unused labour without the necessary capital or land will not, therefore, give rise to secondary effects.

4.11 Exploration and promotion; data needed

As pointed out in section 4.2, there is a need for exploring and promoting new projects in addition to appraising the ones already proposed. Clearly, it is difficult to get adequate information about "all" the "possibilities" of a country; they will often be discovered by chance, or by the imagination of a few persons and are not administered systematically. Geological and sociological surveys may sometimes uncover possibilities offered by natural conditions or human skill. The idea has been put forward¹⁷ that a clearing house be created for the presumably large quantities of information accumulated in crude form in a number of agencies, such as the International Bank for Reconstruction and Development, and the United Nations Bureau of Technical Assistance Operations, an unknown number of consulting engineering firms, government administrations, etc. Although the amount of work involved in making such information useful must not be underestimated, the idea deserves further exploration. For the time being, each government will have to look for ways to collect at least some information; perhaps the institutions mentioned can provide help, additional to that provided in the past.

These remarks also partly answer the question as to the data needed for that part of development programming which is discussed in this chapter. Such data refer, first of all, to the technological characteristics of the project, to the outputs to be expected and to the inputs needed. Next, they refer to the same characteristics for the industries supplying inputs or processing the outputs. Some general information about the operation of the economy, as, for instance, the import contents of expenditures by different consumers and industries, is also needed. The data needed for the planning methods described in chapter III are therefore also needed in the present phase.

¹⁷ "United Nations Advisory Committee on the Work Programme on Industrialization" (E/3213; February, 1959).

Chapter V

PLANNING THE DEVELOPMENT OF A LARGE NUMBER OF SECTORS

5.1 Introductory: The need for sectoral planning

In our discussion of methods for appraising individual investment projects, it has become clear that all investment projects are more or less interrelated. In practice, however, these interrelations are often neglected; even more frequently is their significance underestimated. They may be considered as various forms of complementarities. For instance, it does not make sense to establish a factory without providing transport facilities or the necessary power. Nor does it make sense to build secondary schools in an area without primary schools.

One experience in the United States may be mentioned here as an example. In the summer of 1945, an effort was made to forecast the level of steel production and its relation to total unemployment, for the year 1947. Since a sharp decline in the demand for steel for production of munitions was expected after the war, much excess capacity was thought to be almost unavoidable. Although the demand for residential housing would become considerable after the war, the direct effect of housing projects did not seem to require so much steel. It was discovered, however, by using a model which carefully accounted for all the interrelations among various sectors, that residential construction requires a large amount of steel indirectly by demanding varieties of materials whose production needs steel. On the basis of this type of model it was rightly predicted that there would not be much excess capacity in the steel industry.

Without carefully designed models of the national economy depicting all the inter-industrial relations, the detailed input-output relations among industries can hardly be grasped. For instance, an investment in one industry requires the input of raw materials from many other industries, whose production must be increased; hence more investment must be made in these industries. The industries selling the outputs to them must also be taken into consideration. This endless process of considering all the interrelations can be put into a model called "input-output analysis" or "inter-industrial analysis".

This kind of analysis is already widely used in many countries for development programming and other purposes. The best way of establishing sectoral plans is perhaps to make full use of this type of model.

5.2 Interrelation in current inputs

Two types of inter-industrial relations must be considered. The first is the relations which connect one industry with another through sales and purchases of current inputs. To produce steel, coal is needed. In mining coal, electricity will be used. The amounts of raw materials needed to produce a unit of steel will be determined by the type of technology in use. Given the technology, the amount of current input needed to produce a unit of steel is likely to be constant. The ratio may be calculated by dividing the amount of current inputs used to produce, say, steel by the total amount of steel produced in the same year. This constant relationship may very well be used as a basic coefficient in the analysis of inter-industrial relations. Ratios of this type are sometimes called "production coefficients" or "input coefficients".

Suppose that there are two sectors in the economy; (1) Industry I, (2) Industry II, and suppose also that the transactions of current inputs between them are as follows:

TABLE I—CURRENT INPUT-OUTPUT FLOWS

From \ To	Industry I	Industry II	Total production
Industry I	60	40	300
Industry II	30	80	200

A figure 60 at the top-left corner of the table shows that 60 worth of product of Industry I was sold to (or used by) Industry I itself. A figure 40, right next to 60, indicates that 40 worth of product of Industry I was sold to (or used by) Industry II. Looking at the table horizontally in this way, one observes the sales of each sector's output. However, reading the figures in each vertical column, one can see the current inputs of each sector from various sectors. Table I shows only part of intersectoral transactions related to current input, so that the sum of the figures in each row does not add up to total production. But if all sales, such as those consumed or exported, are included in the table as is done in table V below, then the sum of each row must necessarily be equal to the total production.

Given this table, the input coefficients may be computed as follows:

TABLE II—INPUT COEFFICIENTS

	Industry I	Industry II
Industry I	0.2	0.2
Industry II	0.1	0.4

5.3 Inputs for investment

Any industry must purchase not only current inputs but also the inputs needed to expand its capacity. As explained earlier, there is a certain relationship between the capacity level of output and the amount of capital in the form of various types of equipment. This relationship is expressed by a ratio which may be called "sectoral" or "industrial capital-output ratio". Suppose that this industrial capital-output ratio is, say, 8.0 for the electricity industry. It means that 8.0 worth of capital goods must be invested to increase capacity output by one unit.

Since the industry must purchase a number of capital goods, such as steel, machines, timber, etc., it is natural to split the capital-output ratio according to the kind of inputs to be purchased for investment. For example, the capital-output ratio of 8.0 for the electricity industry as a whole may be made up of construction 5.1, machines 2.4, and so on. Clearly, these "sub-sectoral capital coefficients" must add up exactly to the industrial capital-output ratio. They show what kind of combined capital inputs are required to increase the capacity of the industry in question by one unit. Knowing these sub-sectoral capital coefficients, one could tell the amounts of capital goods needed to expand the capacity of the industry by such and such an amount. To increase the capacity of the electricity industry by 10, 51 worth of construction and 24 worth of machines will be necessary. Conversely, one could say that if inputs are provided of 51 in construction activity and of 24 in machines and so on, the expected increase in capacity will be 10.

Let us take the numerical example of the previous section and elaborate it further to take into account this kind of inter-industrial relations. Suppose that the goods produced by Industry I are sold, for the purpose of investment, to Industry I by 7 and to Industry II by 6, and that the products of Industry II are similarly sold to Industry I by 28 and Industry II by 18. These capital transactions may be shown by the following table:

TABLE III—CAPITAL INPUT-OUTPUT FLOWS

	Industry I	Industry II
Industry I	7	6
Industry II	28	18
TOTAL	35	24

Let us assume, then that the industrial capital-output ratios are 5 for Industry I and 3 for Industry II. By applying these coefficients to the total investments of both sectors respectively, we can obtain the increase in capacity of the two sectors, i.e., 7 in Industry I and 8 in Industry II.

To put the same matter in a slightly different way, suppose that we know the amount of output in each sector available for investment; namely, 13 of Industry I's output and 46 of Industry II's output. How much increase in the capacity of each sector could be expected? The answer to this question can be given in the following way. Table III shows that the capital-output ratio 5 of Industry I may be split into two sub-sectoral capital coefficients at the ratio of 7 : 28 and that of Industry II, 3 at the ratio of 6 : 18. This gives us the following table:

TABLE IV—CAPITAL COEFFICIENTS

	Industry I	Industry II
Industry I	1	0.75
Industry II	4	2.25
Capital-output Ratio	5	3.00

It must be clear that the capital input of Industry I from Industry I can be computed as $1 \times$ (increased capacity in Industry I), and that the capital input of Industry II from Industry I must be equal to $0.75 \times$ (increased capacity in Industry II). The sum of these two capital inputs must be equal to the total output of Industry I left for investment; namely, 13. Exactly the same thing can be said about the capital input of Industry II's output. That is to say, we have the following equations:

$$1 \times (\text{Industry I's capacity increase}) + 0.75 \times (\text{Industry II's capacity increase}) = 13$$

$$4 \times (\text{Industry I's capacity increase}) + 2.25 \times (\text{Industry II's capacity increase}) = 46$$

Given these four coefficients and 13 and 46, but not knowing Industry I's capacity increase and Industry II's capacity increase, we can determine the latter two unknowns by these two equations. The answer is, needless to say, 7 and 8. This is a kind of use of sub-sectoral capital coefficients which is essential for development programming, as will be explained in section 5.8. The principle used here can apply to the case of many sectors as well.

5.4 The over-all balance of intersectoral transactions

Let us continue to use this numerical example and see how the surplus of the production in each sector can be used beside the current and capital inputs. Obviously it must be sold to households for consumption or exported. If, however, the sum of inter-industrial current and capital inputs *plus* consumption *plus* exports exceeds total production, the difference must be imported. Suppose, then, that the balance for our numerical example is kept by those figures in the following table:

TABLE V—INPUT-OUTPUT TABLE

			Investment		Consump- tion C	Exports E	Imports M	Total X
	Industry I	Industry II	I ₁	I ₂				
Industry I	60	40	7	6	167	30	— 10	300
Industry II	30	80	28	18	74	20	— 50	200
Income Payments	210	80						290
TOTAL	300	200	35	24	241	50	— 60	

As this table shows, the row sum of the sales of industrial output must be equal to the amount of total production ($60 + 40 + 7 + 6 + 167 + 30 - 10 = 300$ for Industry I). This means that the demand for a sector's output is *ex post* equal to its supply. This sum is, furthermore, equal to the column sum of each sector's inputs including the payment of wages and profits. This column-by-column summation is made possible by the use of money values to fill in the figures in this table. The column sum, unlike the row sum, is meaningless for physical units.

Looking at all these relationships from the viewpoint of development programming, it is of great importance to notice that this "input-output table" takes into account all the inter-industrial relations, so that it is unlikely for any links between various sectors to be missed in the practical application.

5.5 Statistical compilation of input-output table

The statistical method of constructing this table is somewhat different from the way of reading the table. In empirical works, the first figures we can obtain are those of total production. What we need in order to obtain the value of total production of each sector are the physical quantities of production of the commodities belonging to that sector, and the average prices of each commodity during the year. By multiplying the price and the quantity of production of each commodity and then adding them up, we find the total value of production for each sector. The second step is to fill in the sales to final demand sectors like consumption and export. These figures can be obtained from consumption and foreign trade statistics. Then, subtracting this part from total production, and adding the import of commodities similar to the products of the sector, the sum of the sales to other industrial sectors can be obtained. The third step is to fill in the figures of intersectoral current inputs and capital inputs. In practice, however, the statistical data on capital transactions are often hard to find in existing statistics and very difficult to compile. What is usually done in the absence of adequate data for intersectoral capital transactions, is to be satisfied with the data for the total amount of each sector's output allocated for the purpose of investment. This means that, in the numerical example of table V, the sum of 7 and 6 for Industry I and that of 28 and 18 for Industry II are known, but their sectoral sub-divisions are not specified.

The statistical allocation of current inputs can be traced in two ways. One way is to trace the sales of each sector's output; another is to go after the inputs of each sector, a method which may be supplemented by technical data. The information from these two sources seldom coincides. Checking with each other, one can improve the quality of statistics to a great extent.

If data are available, a similar procedure may be adopted for capital transactions. It is important, however, to point out that a single input-output table, including the capital transactions, can hardly be good enough to compute the sectoral and sub-sectoral capital coefficients.

In order to compute them, at least the data of sectoral production over a few subsequent years are needed. It is preferable to have similar data on intersectoral capital input and sectoral output for the following years, and technical data for the capacity level of production in each sector and the degree of capacity utilization in those years.

5.6 Final bill of goods and level of production

Now we turn to the practical use of this input-output table. There are a number of ways of using this kind of model in development programming. We shall briefly explain some methods for making more complete economic plans. As was explained in the previous section, sectoral and sub-sectoral capital coefficients are more difficult to obtain than input coefficients. It is still very useful, however, without capital coefficients, to use the input-output table for the determination of the level of production in each sector for a given "final bill of goods", which means specified amounts of consumption, investment, exports and imports for each sector's output, but not the demand for inter-sectoral current inputs. In the above example, given the final demands for Industry I's output (F_1) and Industry II's output (F_2); that is, $F_1 = 200$ and $F_2 = 90$, we can find the level of Industry I's production (X_1) and that of Industry II's production (X_2) which are consistent with F_1 and F_2 . As explained in section 5.2, the current input of Industry I's product by Industry I is equal to $0.2 X_1$, and the current input of Industry I's product by Industry II is $0.2 X_2$. Adding up these inter-sectoral inputs, and subtracting the sum from the total production X_1 , we obtain the supply of X_1 available for final demand, which is assumed given now. Thus, in this balancing condition we have two unknowns (X_1 and X_2). However, in a similar way, we can obtain another balance for Industry II which contains two unknowns (X_1 and X_2). These two equalities give us just the same number of equations as the number of unknowns to be determined. If, therefore, we can devise a method of deriving the sectorally divided consumption, exports and imports from the aggregate quantities which we must know in our previous macro-models, we can determine the level of production in each sector. It should be remembered, however, that this does not give the sectoral division of investment decisions in which we may be most interested for development programming, and also that no capital coefficients of any sort are used. Without the knowledge of industrial capital-output ratios, this seems to be the only way of applying input-output analysis. This simple method is, however, very useful, if supplemented by some additional information on labour-output ratios and import functions.

5.7 Problems of employment and learning curves

It is natural to assume that the number of workers employed in each sector depends on the level of its production. The ratio of the former to the latter is called the labour-output ratio, or the labour coefficient, and is sometimes assumed to be constant. This is nothing but the reciprocal of labour productivity in each sector. Given these labour coefficients, we

can determine the sectoral level of labour employment for the level of production in each sector. By adding them up, we know the level of total employment.

It is more realistic, however, to assume that labour productivity changes steadily, and this change can hardly be neglected in making a long-range economic plan. It has been found that, in many cases, labour productivity in each industry, as well as that in the national economy, rises steadily as the level of its production goes up. The relation between these two has been empirically studied under the names of "learning curves" or "progress functions". Whatever functional forms may be assumed for them, common to all of them is the fact that the level of sectoral employment is determined by the level of production in each sector.

5.8 The import functions

In macro-models, imports are assumed to depend on total national product—gross or net. In models with several sectors, a more precise treatment is possible. In general, imports of raw materials depend on the levels of industrial activities, imports of capital goods depend on the levels of investment in the sectors which require those capital goods to increase their capacity. The import of different kinds of commodities, therefore, will depend upon these various economic activities. It is possible and preferable to estimate empirically the functional relations between the levels of economic activities and the corresponding imports—the import functions. This implies a reduction in the degrees of freedom of our sectoral model, where so far imports were treated as free residuals. Formulating our problem in this way, we have only to assign the values of consumption, exports and investment. Given the expected values of these quantities, we can determine the levels of industrial production and imports. All this implies that the industrial structure of the economy is geared, so to say, in the direction determined by consumption, exports and investment.

5.9 Dynamic input-output system

Investment, however, is not really a final demand like consumption and exports. It is one of the quantities dependent on consumption and exports. Particularly from the point of view of development programming, it is most important to consider the problem of allocating capital goods between industries in an efficient way. This problem can be solved by the dynamic input-output system that we have outlined above.

The practical approach would be the following. Assuming that a three-year economic plan is to be drafted, and that we already know from

our calculations in aggregative models at least the levels of national income, consumption and exports for the coming three years, the first thing to do would be to determine the future levels of *sectoral* consumption and exports. Next, we would have to find out the capacity level of each sector's production. Given this, we can compute the inter-industrial current inputs by applying the input coefficients as explained in section 5.6. Subtracting these current inputs and consumption and exports from the capacity level of production and adding the amount of imports related to any of these quantities, we can obtain the amount of each output available for investment. Then, if we know the inter-sectoral capital coefficients, the method described in section 5.3 is applicable. We can calculate the increase in the capacity of each sector. This increased capacity will determine the capacity level of production in the second year, which is the starting point of similar calculations for the coming years. This is how the dynamic input-output model may be used to build up a long-term economic projection. In the use of the model for an economic plan, however, the capacities will have to be chosen in an *optimal* way, so as to make the maximum contribution to national income; this may imply adaptations in exports. After each calculation, moreover, some adjustment in the values of the coefficients used will probably be needed as a consequence of recent experience. Repeated recalculation will certainly produce a more consistent and satisfactory economic plan.

5.10 Efficiency in capital accumulation

There are, however, some complications which must be considered in connexion with the practical application of the dynamic input-output system. The first complication is the possibility of excess capacity in some sectors during the planning period. It may happen, for example, that in the second year of a projected economic plan the productive capacities of some sectors are greater than necessary to satisfy all the prescribed demands. The excess capacities may or may not be eliminated by changing the total level and composition of consumption. Since, however, not all changes in consumption are possible at short notice, and the rigidities and discontinuities in capital coefficients cannot be eliminated entirely, it may be impossible to attain full capacity in every sector of the economy for any feasible set of sectoral consumption levels. If there are several indifferent sets of sectoral consumption levels which will leave some sectors with excess capacity in one way or another, then there remains the problem of choosing alternative investment plans corresponding to each feasible set of sectoral consumption levels. It is clear that, in such a case, it would be more advantageous to choose an investment plan such that the increased capacities under that plan satisfy as much as possible the needs determined by the prescribed consumption and exports in the third year. This more

advantageous path is called an efficient path of capital accumulation. Choosing the path of capital accumulation in this efficient way involves a kind of choice which cannot be avoided in dynamic programming. This type of problem, involving inter-temporal choice of efficient paths of capital accumulation, can be formulated more precisely only in terms of linear programming models.

It would suffice to say here, however, that when there is no radical change in the composition of consumption and exports during the planning period, this kind of case is unlikely. Or, if there is, the degree of excess capacity will not be too serious. We could almost always accumulate more capital with the full utilization of capacity.

5.11 Introduction of new technologies and new industries

Another important complication arises when we have to consider the introduction of new technologies to produce the kinds of commodities already existing in the economy and to consider establishing entirely new industries. These two problems are very important in development programming.

The latter problem is relatively easy to handle. The industries whose introduction is being contemplated may be added to the existing industries simply by increasing the number of sectors in the economy. We certainly need to know the input coefficients and capital coefficients of the new industries. These data must be obtained from foreign experience or directly from technical sources. Then the procedure is the same as just described.

The former problem introduces one complication which makes it difficult to apply the input-output system in a simple way. One of the basic assumptions in input-output analysis is that each industry produces one kind of output and uses one set of technical coefficients. But if we introduce another technology to produce the same output, we have two technologies for one industry. A simple way of handling this situation would be to use some weighted average of the two technical coefficients. Since, however, we do not know the extent to which the new technologies are used, we cannot determine the weight to attach to each technology. Hence, we must rely on the more elaborate method of linear programming if this problem is to be dealt with adequately.

5.12 Variable coefficients

There is one more complication, which can be dealt with in the framework of input-output analysis. It is often argued that such technical coefficients as input coefficients or capital coefficients change with time.

This does not necessarily mean that the methods based on the assumption of constancy of these coefficients fail completely. For there are a number of devices by which we can overcome this difficulty. We may be able to project future coefficients by using technological data or by extrapolation of past trends, or we may be able to obtain the functional relationships between inputs and the level of production within the range of linear approximations. These cases can be handled by slightly modified input-output models. If, however, the changes in coefficients are due to changes in product-mix of an aggregated sector, then it may be necessary to increase the number of sectors. Finally there are some situations which require more than sheer modification of input-output models, especially the existence of alternative methods of production. Linear programming models could deal with difficulties of this sort.

5.13 Characteristics of linear programming models

Dynamic input-output models are very useful but, as has just been pointed out, have some shortcomings which must be overcome in development programming. This can be done by supplementing them with linear programming approaches. The two main shortcomings are:

- (1) Input-output models do not consider the technical substitutability of inputs to produce the same commodities. They are inappropriate for purposes of discussing the choice of techniques in development programming.
- (2) Input-output models do not permit the consideration of boundary conditions which must sometimes be taken into account in development programming. Limitations of scarce resources or social considerations of various sorts can be formulated in the form of inequalities.

Thus linear programming is a natural extension of dynamic input-output analysis. Although many models are conceivable, we shall describe here, as simply as possible, the main characteristics of linear programming models by way of example. Let us assume that we know the capacity level of each sector, all input coefficients and capital coefficients, the expected amount of sectoral exports and the level of sectoral consumption which we aim at as a fixed target. We may or may not have more sets of technological coefficients than the number of sectors. Now the crucial question is how much investment must be made to attain these levels of consumption and exports. Obviously the less investment is needed, the better, because then we can think of raising our targets of income and consumption.

In order to meet the production requirements, we must invest in all sectors. The point is, then, to minimize the total amount of necessary investment. But, as we already stated in previous sections, there are a number of conditions which we must keep in mind when determining the optimum path of capital accumulation. It is a great advantage in linear programming models that we can take into account these imposed conditions at the same time. The way of setting these conditions out differs from one model to another. By and large, however, the following set of structural relationships must be explicitly stated:

- (1) A set of production functions in the form of an input-output table in section 5.4;
- (2) A set of supply functions for imports and demand functions for exports;
- (3) Specifications of the productive resources available.

5.14 A linear-programming model

To clarify the formulation of linear programming models, we shall state those conditions in a specific example.¹⁸ Let us first list the conditions which our economic plan must satisfy:

- (1) Total demand for all goods produced by a sector must be equal to the total production of the sector *plus* imports. Here total demand consists of the inter-industrial inputs related through input coefficients to the levels of sectoral output; the prescribed sectoral consumption and exports; the inter-industrial capital inputs related through capital coefficients to sectoral investment.
- (2) The level of each sector's production cannot exceed its capacity level, which is the sum of the initial capacity and the additional capacity created by sectoral investment during the relevant period.
- (3) The total value of imports cannot exceed the value of exports by more than the maximum deficit permitted.
- (4) The demand for labour cannot exceed the available labour force.

These conditions are used in most linear programming models. Nothing prevents us, however, from imposing some additional conditions. The reasons behind those conditions may be political or social, as well as economic. Some examples may be listed.

¹⁸ For a specific numerical example, see Chenery, H.B., "Development Policies and Programme", *Economic Bulletin for Latin America*, March 1958.

- (5) The percentage of employed workers to total labour force should exceed a certain proportion. This sets the minimum requirement for employment.
- (6) The production of some commodities or the capacities of some industries may have to exceed the demand levels, for example, in order to provide for emergencies.
- (7) There may be some scarce natural resources whose maximum supplies must be specified.

Linear programming techniques enable us to meet a number of such boundary conditions while maximizing or minimizing a certain linear function of variables. Thus we may try to maximize consumption at a certain future time or during a certain period.¹⁹

5.15 Data needed

The methods discussed in this chapter involve the most advanced techniques of dealing with over-all sectoral economic plans. Data needed for this type of analysis are very numerous.

The input-output table, as well as the matrix of capital coefficients, are indispensable. The demand functions for every sector's output, both from domestic sectors and abroad, must be estimated. Labour coefficients must also be known. For the application of linear programming methods, not only the coefficients of processes actually carried out, but also of possible alternative processes must be known.

One important factor to remember in the application of these methods is the limitation in computational equipment. It is not impossible to obtain the solution of a model of 10-15 sectors simply by means of desk computers. Since this type of models must include more sectors, it is desirable to have high-speed electric computers. For a model with 15-20 sectors, for example, IBM 602A or 604 may be good enough, but for a model with sectors over 20, it is desirable to have machines of higher speed, such as IBM 650. Without this equipment, one could not use this type of analysis except for experimental model-building.

¹⁹ If the foreign exchange earnings per unit of exports depend on the level of sectoral exports, then condition (3) is no longer linear but quadratic. This complicates the computation necessary to obtain the solution of this problem, but it is nevertheless possible for this non-linear model to have a unique solution.

Chapter VI

PLANNING THE DEVELOPMENT OF DIFFERENT REGIONS

6.12 Introductory

Development plans of most countries include, besides over-all national targets, some programmes for the development of their different regions. As with other aspects of programming, the choice of technique for dealing with the regional aspects of the programme will depend on the aims set. Some broad types of aims can be distinguished, and a decision must be taken regarding them before planning can start. First, the aim might be to maximize physical product. Development of different regions might then be unequal, and policy might be designed to encourage the population to move to the best location, even though psychological resistance to such movement may be strong. Second, policy might aim at deliberately sacrificing some potential increases in output in deference to people's wishes to stay where they are and spread employment as evenly as possible. Third, the government might even aim at making incomes in different regions as equal as possible; in that case, still another solution will emerge from analysis. Finally, a government might aim at "balanced growth" among regions in some other sense, e.g. the same rate of increase in income. The target rates of expansion of output in various regions would then bear certain fixed relations to each other, and these relations would have to be considered in programming.

6.2 The role of mobility and transportation costs

It is essential to distinguish two types of sectors. The simplest approach is similar to the method often used in the theory of international trade, namely, to make a distinction between production factors which cannot move and production factors which move freely. This distinction amounts to assuming that some *sectors* have a pre-determined location, while others have not. Sectors of the former type, to be called *immobile*, are agriculture,²⁰ mining, importing and exporting (which must take place in some harbours), linked physically with some geographical area; and

²⁰ It is, of course, possible to shift agricultural population from one part of a country to another, but agriculture must take place where there is reasonably fertile soil, rain fall or irrigation water, etc.

a number of services (retailing, housing and personal services) linked with the population. Sectors of the latter type, to be called *mobile*, include most manufacturing processes.

A more precise approach consists of a further splitting up of the mobile sectors according as transportation costs are negligible or not. Only the first category is completely mobile. The location of the second category of sectors requires the solution of some optimum problem in transportation costs, sometimes intimately connected with a problem of optimum size of the plant. Transport may be regarded as a separate sector, and the required expansion of transport facilities derived from the projected levels of other activities. The *initial* transport facilities, however, may be taken as a datum.

Apart from this aspect of the problem there may be differences in production costs for the same sector in different regions. These may be due to differences in the quality and price of raw materials and of labour, availability of water, power and other facilities.

6.3 Rigid regional composition of inputs

A simple approach to the problem of regional planning adopted by some writers starts from an assumption not based on any of the principles of regional planning just enumerated, but from a device simplifying calculations. It is assumed that the inputs of any sector in any region are obtained from other regions in constant proportions.²¹ If the spinning industry in region r_1 has taken raw cotton from regions r_2 and r_3 in the proportions 30 per cent and 70 per cent in the base year, then this proportion is assumed to be maintained in subsequent years. It will be clear that this procedure fits completely into the system of input-output analysis; all that is needed is to enlarge the number of sectors. Instead of the textile industry of the country representing a single sector, we have as many sectors as there are regions with a textile industry. The total input coefficients may or may not be assumed to be the same in all regions.

6.4 Neglecting transportation costs but assuming some industries to be mobile

A better approach would seem to be one based on a sub-division of industries into immobile and mobile ones. An example is given here to illustrate the method; many other cases are conceivable. For purposes of exposition, it may be assumed that there are only three sectors:

²¹ Where a plan calls for sharp changes in the regional structure of production, this approach is of course inappropriate.

First, a sector whose location is determined by the availability of natural resources, to be called generally "mining".

Second, a sector whose location is determined by the geographic distribution of the population, to be called "services".

Third, a mobile industry to be called "the textile industry".

(I) POPULATION IMMOBILE

Suppose now that as a first problem it is required to let the population stay where it is and to develop industries in the various regions in such a way as to make income per head outside "mining" as equal as possible. We can make three further assumptions to delimit this case:

- (a) a plan for the country as a whole has been made, sub-divided into the three sectors, "mining", "services", and "textiles".
- (b) the regional sub-division of "mining" is known from a partial study.
- (c) prices of "mining" products are known and given, implying that the incomes earned in the "mining" industries of each region are also given.

On these assumptions, total income of the nation for the planning period and income earned in mining in each region are known.

The main unknowns of the problem evidently are the quantities of textiles produced in the various regions. On these depend the values of the services to be produced in each region, since these are assumed to be dependent on the regional incomes which are themselves composed of the incomes earned in mining, textiles and services. The incomes earned outside mining can, therefore, be expressed in terms of the quantities of textiles produced in each region, the main unknowns. Since these incomes, taken per head, should be equal for all regions, and since all regional income has to add up to total national income, which is known, we have just sufficient conditions to fix the main unknowns.

There may be complications with what are technically called "boundary conditions"; for example, planned mining production may occupy so many people that insufficient numbers are left to produce services. This may point to the necessity of revising the figures given for mining production. There may be other similar problems. Their solution depends so much on the factual situation that a complete discussion seems to be out of place.

(II) POPULATION MOBILE

Another type of problem arises when movements of the population are admitted. In this case, the target level of national income is not predetermined, but depends on how projects are distributed geographically. The population movements required may be significant if the average income in the textile industry differs among regions. If resistance to movement is ignored, the nation's income can be maximized by concentrating textile production in the region where it yields highest incomes, i.e. the regions with lowest cost. Population figures of the regions are now the unknowns; they have to obey the conditions that all the textiles needed are produced in the region or regions where textiles are produced at the lowest cost, while in all regions sufficient people must be available for the service industries. Comparison of the results obtained from problems I and II may help in the choice of policies regarding regional development.

Models of the type just described need not be restricted to three sectors. There may be many more in each class of sector, and problems similar to those used for illustration can be solved along the same lines.

In practice, population will be neither completely mobile nor completely immobile. By "partial research", an attempt may be made to estimate the maximum numbers which will move voluntarily. These could then be entered as boundary conditions into problem II, which opens up a possibility of solving the more general problem of determining the optimum distribution of mobile industries over the regions in case of partial mobility.

6.5 The introduction of transportation costs

A still more realistic approach will be obtained when the fact is recognized that transportation costs are not always negligible, at least not for all types of commodities. This fact makes it necessary to introduce further data into the model, namely the costs of transporting any commodity h from one region r to another region r' . There may now be differences in the price of the same commodity in different regions. The mechanism of competition between suppliers of the same commodity in different regions may be simplified—for the sake of manageability of the figures—in different ways.²²

To clarify ideas, one possible formula may be discussed here. In this formula (to be called the one of finite elasticities of substitution) the price in region r of any product h originating from region r' , is assumed

²² Cf. J. Tinbergen, "The Appraisal of Road Construction: Two Calculation Schemes", *Review of Economics and Statistics*, XXXIX (1957) p.241.

equal to its price in region r' plus transportation costs from r' to r . The same product h may have then different prices in the same region r , depending on the region where it was produced. It is then assumed that total demand for that product in region r is distributed over the region r' according to a relation with finite elasticities of substitution. In other words, more will be demanded from region r' the lower the price of r 's product in region r is, but, even when prices of product h from other regions are lower, some quantity will still be demanded. The alternative is to assume that region r will buy commodity h only in the region r' which can supply h at the lowest price; we may label this method the "system of infinite elasticities of substitution". Although conceptually simpler, this device is more difficult to use in calculations.

It is possible to construct a planning model for regional planning along these lines. The advantage of such a model is that it does not neglect a phenomenon, namely transportation cost, which in bigger countries plays a role of some importance, especially when transport facilities are restricted. The model becomes rather complicated and can be described in an accurate way only with the aid of formulae. An example of such a formal construction is given in the appendix to this chapter.

The equations appearing in the model shown in the appendix set forth ten groups of conditions. The nature of each set of conditions may be briefly characterised in the following summary, where the numbers before the paragraphs correspond to the group number of the equations in the appendix:

- (1) The total quantity of each good produced in each region must be equal to the sum of the quantities shipped to all regions.
- (2) The total quantity of any good used in a region must be equal to the sum of
 - (i) consumption, itself dependent on income *minus* savings and the price level of the commodity;
 - (ii) deliveries to other sectors in the region, for current production;
 - (iii) deliveries to other sectors in the region, for investment;
 - (iv) exports.
- (3) Deliveries for current production of sector h to sector h' , in any region, must be proportional to the volume of production in sector h' .
- (4) Deliveries for investment of sector h to sector h' , in any region, must be proportional to the rate of increase in production of sector h' at some future date.

- (5) All investments in all regions must add up to the nation's savings.
- (6) The income for each region, assuming that transportation income accrues to the region from which the goods transported originate, is defined.
- (7) Saving of each region is related to income of that region.
- (8) The price obtainable for each product in each region depends on the quantity produced in that region and the quantities produced in other regions.
- (9) For a given product, demand exerted by any region for quantities produced in other regions depends on the relative prices at which these quantities can be bought.
- (10) Average prices paid for each product in each region are a weighted average of prices of that product in that region, originating from the various regions.

It should be added that the supply side of production is expressed by choosing the production capacities of the various sectors in such a way as to maximize national product.

It will be clear that there is a large number of variants to this model and that many details will have to be fixed in accordance with the special features of the country, the sectors and the regions concerned.

6.6 Data needed

A large volume of data is needed before programming techniques of the kind discussed in this chapter can be undertaken. A minimum requirement is that production and family consumption data for each sector of each region are known. In addition, for each sector current inputs, and investment inputs, should be known separately. On the assumption that production costs of a given commodity are equal in all regions, one may then derive the other figures needed, but it is better—and in fact indispensable for the models assuming differences in production costs—that data be also available concerning possible differences in production costs, i.e. differences in inputs-per-unit-of-output between regions. For the models discussed in section 6.5, data on transportation costs should be also available. With regard to some of the elasticities, particularly those determining the competition between regions and those concerning world market demand, it may be possible to make reasonable guesses from published econometric studies.

Chapter VII

PLANNING THE SHORT-TERM ADJUSTMENTS TO EXTERNAL DISTURBANCES

7.1 Introductory

Any economy, whether developed or under-developed, is subject to short-term fluctuations generated by international and extra-economic factors. International factors of considerable importance to most economies in the region are the volume and prices of exports, and import prices. Extra-economic factors may be crop yields and political events, or technical changes. These phenomena affect the economy's income, employment, balance of payments, price level—indeed all “economic variables”. In some years their impact is favourable, in others unfavourable, in a somewhat random fashion.

7.2 Adjustments to short-term external disturbances

These short-term fluctuations may either endanger the attainment of long-term goals of the development plan or engender undue optimism. Government policy should be designed to dampen these fluctuations with as little deviation from the long-term plan as possible.²³ These adjustments can be painful, especially if the disturbances are severe. International stabilization policies can do much to mitigate their severity; but such policies are outside the scope of this Report. The effects of short-term disturbances can sometimes be offset by the use of reserves of some kind; thus, a moderately adverse balance of payments can be met by the release of some of the country's gold stock. However, since the reserves of most under-developed countries are not large, they will sometimes prove insufficient to cope with the situation by themselves, and some adjustment of plans and policies will be necessary.

If income from exports is lower than expected, both investment and consumption may have to be reduced; if the balance of payments is unfavourable, imports may have to be cut either by direct restrictions or by indirect measures, such as tax increases, affecting total consumption outlay.

²³ Policies to offset external disturbances should not be confused with “short-term plans”; that is, plans covering two or three years for establishing the preconditions for long-run development.

It has been customary for a long time, in developed and under-developed countries alike, to deal with such situations in a more or less improvised way. To some degree it cannot be otherwise. The time at which these disturbances occur and their extent cannot be easily predicted. However, stabilization measures can easily be improved in their quantitative aspects. The question of how much imports should be restricted, or taxes raised, was often answered in the past on the basis of crude calculations, taking only direct effects into account. Thus, if an unexpected deficit in the balance of payments of, say, ten million, had to be met, there might be a tendency to restrict imports by ten million. This might mean overdoing the restriction. It might be that the restriction itself lowers the incomes of certain groups, which may lead to a further reduction in effective demand and so in imports. There are other indirect effects as well. Together they give rise to some sort of "multiplier", tending to magnify the initial effect of any measure. Knowledge of such multipliers can be used in order to improve the design of the defensive measures against external disturbances.

In recent decades, a few approximative devices have been evolved, such as the Keynesian multiplier, to calculate total effects of certain types of measures. Meanwhile econometric models have been constructed to serve this purpose better, and to handle a wider variety of cases. Such models are in use in the Netherlands,²⁴ for example; they make possible a more accurate assessment of the policy measures needed.

It should be emphasized that these models may be applied in dealing with short-term changes in external factors that are either upward or downward in character. Many countries may wish to pursue policies of internal stabilization designed to dampen the effects of external fluctuations. These policies would encourage the accumulation of external reserves in periods of rising export prices so as to help maintain imports when such prices fall. When external reserves have been built up the severity of the measures needed to deal with adverse changes are reduced. It is easier in this way not only to stabilize disposable incomes but also to sustain a planned rate of development expenditure in the face of cyclical disturbances. The models for dealing with short-term adjustments could be used in determining the nature and extent of such compensatory stabilization policies.

7.3 Nature of short-term planning models; variables included

The nature of these short-term planning models is different from that of the ones used for long-term development. For the very reason

²⁴ Cf. Netherlands Central Planning Bureau, *Scope and Methods of the Central Planning Bureau* (The Hague, 1956). Another important example can be found in L.R. Klein and A.S. Goldberger, *An Econometric Model for the United States, 1929-1952* (Amsterdam, 1955).

that they have to bring out only the short-term reactions of the economy, they can neglect certain long-term slow movements; on the other hand, most long-term models neglect a number of short-term reactions. Thus, it is well known that in the short run changes in industrial production are mostly due to changes in demand, rather than to changes in capacity to produce. It is also well known that short-term movements in agricultural prices are due to changes in yield per acre, rather than to changes in technology. Since, moreover, the types of measure apt to yield quick results are limited, short-term models can neglect changes in instruments which can only act in the longer run.

The details of short-term models may vary from country to country. They will depend on the instruments used by the government for combating short-term disequilibria, availability of foreign exchange reserves, etc. Their proximate task is to show how changes in these instruments affect the relevant variables of the economy. The relevant variables will be more particularly those for which government policy has targets. Assume, for example, that the government has the following targets:

- (a) a given volume of investment (set forth in the development plan),
- (b) balance of payments equilibrium,
- (c) a stable price level, and
- (d) a given level of employment,

and has at its disposal the following instruments of economic policy ("instrument variables"):

- (i) indirect taxes,
- (ii) direct taxes,
- (iii) non-investment government expenditure (which might include export subsidies or stockpiling),
- (iv) import restrictions,

these eight variables should appear in the model.

The influence exerted by changes in the policy instruments usually work through the intermediary of some other economic variables. A change in government expenditure will affect incomes. Changes in direct taxes will affect disposable incomes. Changes in indirect taxes will affect prices and, together with disposable income, they affect total demand. Import restrictions will change the composition, and probably the level of aggregate demand; and so on. For this reason a number of "other variables" may usefully be added to the list of variables in the model.

The model must reflect the structure of the economy, in so far as it is relevant to the problem of short-term adjustments. This requirement may mean that income should be sub-divided into incomes of the groups of the population to the extent that these follow different spending patterns, e.g. farmers, high urban incomes and low urban incomes.

7.4 Relationships between the variables included

As in all models, the relationships between the variables are the core. They will be of various types, namely: (i) definitions, e.g. the definition of income of some groups; (ii) technical relations, e.g. the relation between volume of production and employment; (iii) institutional relations, e.g. the relation between tax revenue, the tax rate and the tax base; (iv) behaviour equations, e.g. demand and supply relations.

The total number of relations should be equal to the number of unknowns. In the usual "analytical" problems of economics, the unknowns are such variables as prices, wages, income, employment, over which the government does not have direct control. Their behaviour has to be "explained" by the "data"; that is, by the *given* values of the instrument variables and of other "extra-economic" phenomena. In a "policy problem" the unknowns are the "instrument variables" and the "other variables"; the "known" variables are the changes in data and the targets set.

In a number of these relations certain coefficients will occur, such as the marginal propensity to consume of urban low-income-earners. Another example may be the coefficient indicating the cost of living increase to be expected as a consequence of a given increase in farm prices. Such coefficients also reflect the structure of the economy.²⁵

No attempt will be made in this Report to give a complete list of the variables or relations of a short-term planning model, since these differ from one country and situation to another. Examples will be found in the publications quoted.

7.5 Methods of planning a systematic policy²⁶

From some points of view, the best time to make short-term plans is shortly after the figures of the main crops of the country concerned have become available. On the other hand, it is convenient to start short-term plans from budget-day, since annual plans are an important component

²⁵ Cf. N.V.A. Narasimham, *A Short-Term Planning Model for India* (Amsterdam, 1956).

²⁶ Cf. also J. Tinbergen, *On the Theory of Economic Policy* (Amsterdam, 1952); and *Economic Policy: Principles and Design* (Amsterdam, 1956).

of the budget. Complications of this sort will not be discussed here; we would like only to suggest that the gaps between dates in short-term plans and other key dates be made as short as possible.

With these figures available, and some forecasts about the probable situation in the export and import markets of the country, a forecast of the economic situation of the country for the year to come will be undertaken. This forecast will be based on the assumption that no change takes place in the instruments of economic policy. In other words, the model is used for an "analytical problem"; the values of the instruments are given, and those of the target variables, together with the other economic variables, are considered unknowns, as pointed out above.

The result will be compared with the targets of economic policy as the government sees them. If there are no appreciable deviations, no change in policy will be needed. If there are deviations—and this is the case under discussion—the model will be used to solve the "policy problem", that is, the desired values of the target variables are substituted, and the values of the instrument variables are considered unknown. The solution of the system of equations will now yield the values of the instrument variables which should be recommended. They represent the best estimate of the policy calculated to lead to the desired targets.

The results have to be considered critically, and to be checked by commonsense considerations. If they indicate moderate changes in the instruments used, remaining within what seem reasonable limits, they may be accepted. This may be the case when, say, indirect taxes would have to be increased by 5 per cent, direct taxes by 10 per cent, government expenditure to be cut by 2 per cent and imports to be restricted by 2 per cent. But it may easily happen that much less "realistic" values are found, such as a doubling of indirect taxes.

Three questions will then have to be considered.

First, it may be asked whether other instruments should perhaps be added to those already in use, such as rationing of consumer goods. Assuming that the upper limit of indirect taxes which is considered feasible by the government is an increase by 30 per cent, these taxes may be set at this level, and the necessary degree of restriction by rationing may be added as an unknown to the system. If a reasonable figure is found, this may constitute the best policy. It should be noted, however, that the introduction of rationing will require revision of some equations in the model.

Secondly—especially if no satisfactory answer can be found—it may be asked whether the targets should be maintained. A revision may be necessary. Such a revision can now be estimated again with the aid of

the model. By substituting in it the maximum values considered feasible for the instrument variables, the values of the targets can be found which can be attained and the targets may be revised accordingly.

A third possibility has to be explored. It may be that the model used is not realistic, at least not for the range of values of the data which have been forecast for the particular year considered. It may be, e.g., that the external disturbances have shifted the economy into an inflationary condition, where price increases bring no further increases in supply. Some equations may then have to be revised, and the exercise may be resumed accordingly.

These examples all refer to cases where downward adjustments of the rate of development are necessary. If foreign exchange reserves are built up in years of buoyant export markets, however, it may be possible to maintain the over-all rates of growth, despite a subsequent drop in demand for exports or profits on private investment. Subsidizing or stockpiling exports, reductions of taxes and interest rates, can contribute to such stabilization. Another possible device is to adjust the public sector of the development plan upwards.

7.6 Timing public development investment

Within limits and with proper planning, and if foreign exchange reserves have been accumulated in good years, public investment for development can be timed so as to offset external disturbances. This process requires bringing forward public development projects from later years in the programme whenever labour and other resources are released from the export and private investment sectors. As exports and private investment recover, the public development sector can be contracted fairly rapidly, by a decision not to start new projects as quickly as earlier ones are completed. This process of accelerating the pace of public developmental investment to maintain stable income and employment has been called "telescoping".²⁷

Successful "telescoping" requires that the development plan should include a number of projects which can be quickly launched, and which can be completed within a matter of months. Experience indicates that relatively small and labour-intensive projects, of the sort typically financed by regional and local governments, can be more easily started and more quickly finished than heavy construction projects of a kind usually undertaken by the central government. This policy is easier to implement when "rolling plans" are in effect, with annual revision of the plans and

²⁷ For a more comprehensive discussion of the principles and problems of telescoping, see Benjamin Higgins, *Public Investment and Full Employment* (Montreal, International Labour Office, 1956), especially Part 3.

the addition of another year's projects to replace projects already completed. The Philippines, for example, adopts in principle a "rolling plan" approach to development.

Variation in the rate of expenditure on development projects in the public sector has one advantage over other stabilization policies; it affects income and employment in the same period as that in which it is carried out. Other instruments for stabilization, such as variable tax rates, affect income and employment only after a lag.

There are, however, limitations to the use of "telescoping" to offset external disturbances. The executive branch of the government must have authority to vary the rate of developmental expenditure in accordance with the general economic situation; engineering plans must be prepared in advance; there must be some degree of mobility of labour between the export and private investment sectors on the one hand, and the public developmental investment sector on the other; and there must be foreign exchange reserves to maintain imports despite the fall in exports.

If the development programme includes small-scale, labour-intensive projects and if a policy of accumulating foreign exchange reserves in good years is followed, these limitations can be overcome. A more serious limitation is the fact that maximizing the rate of growth of national income in the future may require the execution of projects in the programme in a certain sequence. The projects which would be ideal for telescoping would be those which can be carried out at any time, without affecting the over-all rate of growth during the planning period as a whole. The number of such projects which also meet the other requirements for telescoping may prove to be limited. On the other hand, permitting external disturbances to lead to recurrent cycles of inflation and unemployment will also retard economic growth.

7.7 Data needed

The construction of the models discussed in this chapter requires a considerable quantity of data. Time series of some length—preferably extending over a decade or more—of the variables to be used are necessary if the equations of the model have to be tested. For "telescoping", data on "labour patterns", showing the rate at which projects of different sizes and types absorb and release labour, are also useful. In countries which are the first to apply the method to economies of their type, considerable experimenting may be necessary. Countries following the example, however, may not need to repeat these experiments. For countries where the structure is similar to other countries it may not be necessary to redo all the testing. Results of other countries may be tentatively used, and shorter statistical series may be used for a more superficial test.

Chapter VIII

PLANNING MANPOWER, EDUCATION AND INCOME DISTRIBUTION

8.1 Introductory: Interrelations between the economic, the social and the cultural aspects of society

Economic phenomena cannot be shaped without taking into account some of the other aspects of human life. In the specific field of programming a country's development, one of the clearest examples of a relationship between economic and "non-economic" factors is to be found in the field of manpower planning. Another example of such interdependence can be found in the field of training and education, where the need for planning is just as great as in purely economic development. The interrelations are wider than that, however; a certain level and content of education may not only be a pre-condition for development as such but may be an end in itself. Ideally, planning should cover all interdependent fields, and in the preceding chapters it was tacitly assumed that the necessary measures had been undertaken in all of them. Some of these interdependencies have long been recognized by the responsible international agencies which form part of the United Nations family. The emphasis laid on technical assistance as a complement to capital assistance is one result.

This chapter will devote particular attention to the role of training and education for the assurance of an adequate and appropriate supply of manpower and to facilitate greater equality of income distribution. While training and education can directly increase a country's ability to meet its manpower targets, they also help indirectly to reduce inequality of opportunity and make income distribution less uneven. Since the highly uneven income distribution in under-developed countries is one of their weakest spots, making for potential instability and lack of coherence of society, this indirect effect may well be as important as the direct effect.

Unfortunately, much less precise knowledge is available in the non-economic fields than in the purely economic one, however limited knowledge of the latter may still be. In these circumstances, this chapter can do no more than provide a preliminary orientation. The importance of the subject requires, nevertheless, that some attention be given to it.

8.2 The demand for manpower of various qualifications

As a first step in the analysis, the need for men and women in a large number of different jobs can be linked up with the development of production, as foreseen in the purely economic chapters of a development plan. Both from records of single investment projects and from some general sources of information, some indications can be obtained as to the numbers of skilled workers required in various categories, especially of more highly qualified technicians needed in manufacturing industry. Similar indications can be obtained with regard to other groups of specialists, such as doctors and nurses for the health programme, the total number of trained civil servants needed for the public sector, and so on. In teaching, the situation is somewhat more complicated, since an "acceleration principle" operates there. The quicker the need for training and education expands, the greater the number of those who have to train the teachers or the prospective teachers. To begin with, trial-and-error methods may be used; more refined methods may be applied later.

It seems useful to make a sub-division of estimated manpower requirements between those which are closely linked to production and more or less clearly defined, and others of a more general nature, more indirectly dependent on "what the country can afford". Let us begin with rather traditional and sometimes imprecise classifications of the types of manpower which will have to be used. In a later stage, the more precise descriptions now used in job evaluation may find application.

The type of manpower forthcoming in the initial phases is not exactly what is needed. The economy has at its disposal different methods of adapting itself to this problem: training within industry, importing foreign workers on a temporary basis, or just "muddling through".

8.3 The supply of manpower of various qualifications

Evidently the total supply of any kind of manpower at a future point of time consists of two parts: (i) manpower already present and which may be expected to be still available at that time, and (ii) people—mostly young people—who can be trained in the meanwhile, either in schools or on the job.

In principle, the first component can be estimated from a manpower survey corrected by mortality figures, preferably for specified occupations. To start with, primitive but helpful estimates of available manpower may be derived from census figures, although these will often not be sufficiently precise in describing qualifications. More accurate information is desirable, and has sometimes been prepared by special enquiries, on the basis of

psychotechnical methods and classifications used in job descriptions. The linking-up of the latter two methods constitutes one of the methodological problems of this type of planning. Mortality figures can be applied with some accuracy only when the age of the individuals concerned is also given. Specific mortality figures for separate jobs can sometimes be obtained from insurance companies or social insurance authorities.

The second component of future manpower, namely the "crop" of successful pupils of certain types of schools, can be obtained to the extent that school attendance statistics and statistics on training facilities on the job are available. Programming activities should concentrate on these aspects of labour supply. If an insufficient supply has to be expected with existing training facilities, expansion of such facilities on the required scale has to be part of the development programme.

8.4 The economics of education

The real problem, however, is somewhat neglected if this line of thought is followed. Like every other activity, education is also a matter of investment in which advantages to be obtained should be compared with the costs involved. Of course, no narrow criterion—such as insisting on private profitability of a school as a prerequisite for establishing it—can be applied. The social advantages are far wider than can be measured by the fees people are willing to pay. Some sort of "economics of education" has to be developed, nevertheless, and the first requisite is to have information about the results obtained and costs involved. These results can be expressed in a primitive way by the percentage of pupils who obtain the final diploma, and in a more precise way by assigning weights to each pupil, such as their aggregate marks in examinations. It remains for the future to try to unify the methods of appraisal used in (i) training institutions, (ii) job evaluation and (iii) psychotechnical testing of candidates for a job. Explorations in the social costs and benefits of training will also be needed. Among social costs, production foregone during the training period stands out; among social benefits, the future increase in value of production ranks high.

8.5 Planning training and education

Most of the refined data just discussed are not likely to be available in the countries of the region, and more primitive methods must be used in the planning of training and education. However, some general devices can be suggested.

To begin with, training institutions directly connected with production should be planned to meet future requirements. Thus technical and commercial schools of different levels and types should be designed according to the needs of the economic programme. Some types of university training, such as engineering, sciences and economics may be dealt with in a similar fashion. As already mentioned, a certain minimum of general primary-school education may also be considered a prerequisite for the development of production.

The preparatory stages connected with those directly linked to production are the next category to be considered. If a sufficient flow of pupils is to be obtained for training in stages directly linked to production, a larger number of students will be needed in the preparatory stages. The Ministry concerned may have empirical knowledge of the ratio concerned. A provisional programme for this category can then be made. Depending on the total means available, this programme may have to be adapted, and special measures designed to obtain the desired number of the first category. Clearly, fairly long time-lags enter into computations of this kind.

The third category of training and education is not linked up with future production either directly or indirectly but represents an effort to raise the general level of education of the people.²⁸ The over-all economic situation of the country may not make it possible immediately to reach the levels which educational and medical experts, or statesmen, might want to establish. In that case, a long-term programme is needed. Some guidance may be obtained from international comparisons; the point may be raised whether it would not be important for United Nations agencies to provide data on the relationships between income per head and various indicators of educational facilities and medical standards. Even though international comparisons can only reflect the *status quo*, which should not be considered a norm, governments can obtain guidance from such comparisons. It may well be, for example, that, before establishing higher medical or educational standards, the nation should first have sufficient food and housing.

Once a decision has been taken that—in 25 years, say—a certain standard should be reached, programming should see to it that the numbers of schools and so on are adapted to this decision, and that they are in balance with each other, having in mind the links among the various types of school.

²⁸ The general level of health might also be included in this category of considerations.

Finally, special attention should be given to the interrelation, already mentioned, between the number of future teachers needed and the number of those who have to train these teachers.

8.6 Manpower distribution and income formation

As already stated, the creation of training opportunities may also affect income distribution, and may be deliberately undertaken to facilitate reducing the inequality of incomes, as well as providing manpower. Any individual who becomes a qualified man instead of an unqualified one can earn a higher income, and by this shift the bargaining position of the remaining lowest income earners tends to improve. The general rise in productivity permits redistribution of income without reducing the real incomes of any groups. It may well be a wise policy to pursue greater income equality as an end in itself, within certain limits, in order to arrive at healthier social conditions. In order to attract labour for the "lower" occupations, higher incomes may not be enough. It may be necessary to adapt the content of education to influence attitudes towards these occupations. The limits should evidently be drawn in such a way as to avoid unemployment of qualified manpower. With the possibilities of adaptation of demand, there remains, however, a margin of useful application of the ideas set out here.

8.7 Data needed

From the preceding sections it is clear that exercises of the kind sketched in this chapter can range from immediately applicable but primitive methods to highly sophisticated research, barely started in some of the most highly developed countries. The nature of the data needed therefore varies widely; these have been indicated in describing the techniques themselves.

Chapter IX

RECOMMENDATIONS

9.1 The use of models for the region

Programming techniques are fairly new and their use by the countries of the region, speaking generally, limited. It may, therefore, be useful before we come to our specific recommendations to make some broad remarks on the scope for the use of models by planning organizations in the region.

The use of econometric models presupposes the availability of quantitative information about the variables, coefficients and parameters, which are used to construct them. The range and variety of the information required, of course, varies with the complexity of the model. This consideration has been kept in mind in developing the argument of the report. The discussion begins with the simplest model and proceeds to more and more complex ones, the assumption being that a country will use the model which can be best constructed with the aid of information available to it. The information required for the various models is given in the relevant chapters.

Broadly speaking, one can divide the countries of the region into three groups according to the stage of development of their statistics. The countries in the lowest group, e.g. Afghanistan or Nepal, can try and use the model discussed in chapter II. Some countries in this group may also possibly try the models delineated in chapter III. Countries in the second group represented by, for example, Burma or Thailand, can use the models in chapter II and those in chapter III. Finally, those in the third group, e.g. Japan or India can use the more complicated models discussed in later chapters. However, a country which is in a position to use both simple and complex models need not look upon them as necessarily competitive. The conclusions reached by the use of one model can be used to check those arrived at on the basis of other models.

While the use of all models implies the availability of quantitative data, the simpler models can be tried out with approximate data and with the help of the known values of coefficients in other countries. The results may not be fully satisfactory; but they will probably offer better

guidance than pure guess-work or intuition. Moreover, the attempt to construct a model and use it may orient the planners of a country towards scientific planning and lead to the development of useful statistical data.

9.2 Dissemination of knowledge

We may now conclude with certain recommendations regarding further work in the field of programming techniques. There are, of course, other important aspects of planning such as the implementation of plans and the question of planning machinery. But it is not intended to make any specific recommendations about these.

The recommendations within the field of programming techniques fall into two categories. The first category refers essentially to the wider dissemination of knowledge concerning programming techniques and models amongst planning agencies and similar bodies. The second relates to further improvements of the data and techniques needed for effective programming.

Within the first category, two recommendations are made which merit the highest priority. One of these is the preparation of a practical handbook on programming techniques; the other is the institution of regular training courses within the region for the benefit of the staff of planning agencies.

The Handbook: It is suggested that the ECAFE arrange for the preparation and publication of a Handbook on Development Programming for the use of planning agencies in the Region. The handbook should provide practical guidance on the techniques to be used in dealing with the problems of planning, in particular, on the central problem of interdependency. It should be written for the economists, statisticians, econometricians and other specialists concerned with planning, and should provide information about the simpler as well as the more complex methods that could be used. The handbook should broadly cover the subject matter dealt with in the preceding chapters of the present report; it should provide, in addition, the detailed guidance needed for practical planning.

Training courses: A trained staff is of the greatest importance in the application of programming techniques. The existing facilities for training are, however, extremely limited and are almost exclusively outside the region. Even where courses relating to economic development are provided, they are seldom oriented towards the particular needs of practical planners.

To meet this situation, it is necessary to provide, within the region, regular courses of training in planning work. Although no detailed scheme can be outlined here, some general requirements may briefly be stated:

(i) The courses should be intended primarily for members of the staff of planning departments or related governmental agencies;

(ii) At least one course should be provided every year. A duration of about six months may best suit the convenience of planning agencies;

(iii) They should familiarize trainees with the techniques of programming and their application, with the development plans of various countries, with problems of implementation, and with questions relating to planning machinery;

(iv) The training staff for the courses should be drawn from experts both inside and outside the region and from universities and other academic institutions as well as from planning bodies;

(v) The courses should be sponsored by ECAFE. They might be held in rotation in different countries of the region, and possibly financed by the Technical Assistance Programme or the Special Fund of the United Nations.

Such courses could usefully lead to the establishment of a permanent institute for research and training in planning techniques, located within the region.

9.3 Improvement of data and techniques

The second category of recommendations refers to further work in the direction of improving both the data needed for programming and the techniques of programming themselves. Certain types of work in this category could be undertaken by future Expert Groups. Other types of work, however, may more appropriately be handled by international institutions with facilities for continuing research.

Regarding the work of future Expert Groups, the following subjects of high priority are suggested:

1. COST DATA

The importance of cost data on various industries for efficient programming will be readily appreciated. Yet planners are handicapped by the inadequacy of information in this field. A future Expert Group may usefully appraise the data already available and consider the design of research needed for their improvement.

2. INTERNATIONAL COMPARISONS OF COEFFICIENTS

Analysis of data on coefficients, for example consumption and investment functions, capital coefficients, input coefficients, labour productivity, etc., are of great value for planning purposes. It is important that steps be taken to make such data available, and to determine the extent to which planners can make use of coefficients from other countries. The design of research on these questions is a subject of high priority which may be taken up by a future Expert Group.

3. SHADOW PRICES AND CHOICE OF TECHNOLOGY

A third important subject suited for further study by expert groups is that of the use of "shadow prices" in planning within the region, and the related question of the choice of technology. A brief discussion of the concept of shadow prices is to be found in chapter IV. Nevertheless, there is scope for further study in this field concerning the concept itself, the determining of shadow prices in practice, and the usefulness of these and other concepts in the choice of technology.

Of the subjects and tasks that could be dealt with by international institutions or in other ways, the following should be given priority:

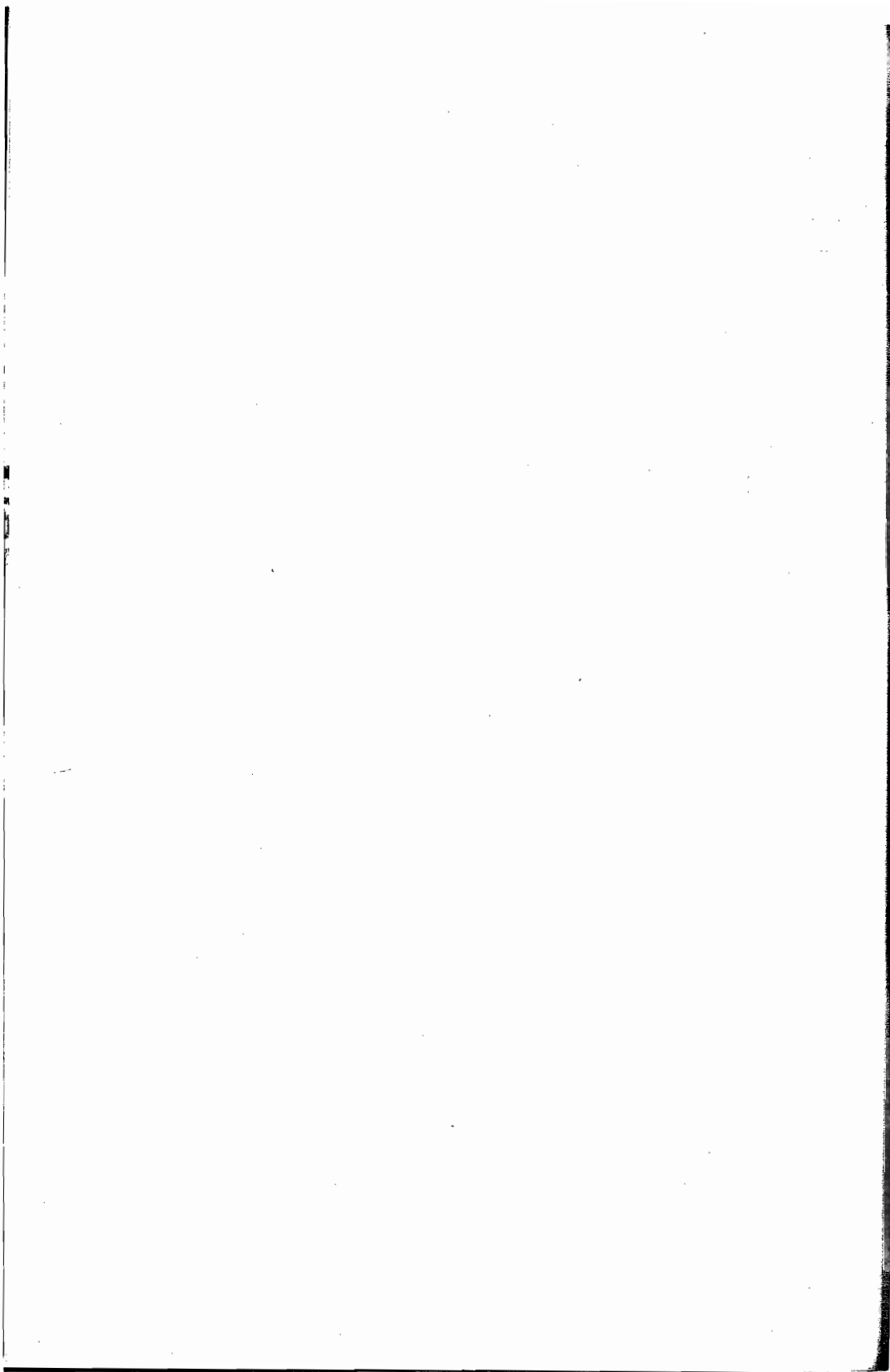
(i) *Forecasts of world demand for major commodities.* Planners in different countries find it necessary to make forecasts of world demand for several commodities in world trade. Needless duplication should be avoided. Because of the influence which such forecasts have on prices and other factors, it is desirable that they be made by a broadly representative international institution.

(ii) *Case studies in the application of programming techniques.* It will be of considerable use both for illustrative and experimental purposes to apply various programming techniques and growth models to the actual situation of specific countries in the region. It is suggested, therefore, that ECAFE should seek the co-operation of member governments for such a project and arrange in the first instance for a suitable team to visit a particular country in order to undertake such a study.

(iii) *Intraregional co-operation in planning.* Effective planning needs to take account of various kinds of interdependencies not only within nations but also between nations as well. Intraregional co-operation in planning through the exchange of information and in other ways can therefore be beneficial. It is suggested that ECAFE should explore the possibility of assisting in such co-operation. ECAFE might also with advantage undertake the preparation of long-term projections of growth as well as other studies of relevance to intraregional co-operation.

(iv) "*Learning curves*". Learning curves throw light on the relationship over time between changes in production and change in the average productivity of labour in respect of the economy as a whole, of individual sectors, and even of single projects. The collection and analysis of data on learning curves in different parts of the world would be of value as an aid to development programming. A study of this subject might well be undertaken by the ECAFE secretariat.

In addition to the recommendations outlined above, the views of the group were sought—in accordance with the decision of the 15th session of ECAFE—on the proposal for a regional meeting of experts to be jointly sponsored by ECAFE and FAO on the problems of target setting in agriculture. This group is of the opinion that in view of the great importance of agriculture in the countries of the region, such a meeting could prove of considerable use. It is important to stress, however, that target setting in any particular sector such as agriculture should only be undertaken in the context of over-all programming. The meeting should consist of economic experts in programming technique and of agricultural experts; the latter would, broadly speaking, contribute special knowledge on the technical and behaviour patterns in the agricultural sector. The former would be concerned with the interdependencies among different sectors, including agriculture, and the setting of over-all targets.



Appendix to chapter II
MACRO-ECONOMIC MODELS

By

SHINICHI ICHIMURA

Model building

The most practical approach to planning the general rate of economic development would be to set a target of economic development in terms of Net National Output or Real National Income and examine the possibility of attaining the target. Since capital is the most scarce factor in most under-developed economies, the model which suits our purpose best is the Harrod-Domar model. This well-known model may be used for development programming in the following way. The basic balance equations are the following:

$$Y' = C^p + I^p + C^g + I^g + E - M \dots\dots\dots (1)$$

$$Y' = Y + T^i = Y^p + T^d + T^i = Y^p + Y^g \dots\dots\dots (2)$$

$$B = M - E \dots\dots\dots (3)$$

- where C^p : Private consumption
 I^p : Private investment
 C^g : Government consumption
 I^g : Government investment
 E : Exports
 M : Imports
 Y' : National income at market price
 Y : National income at factor cost
 T^i : Indirect tax *minus* subsidies
 T^d : Direct tax *minus* transfer payments
 Y^p : Disposable private income
 Y^g : Disposable government income
 B : Foreign loans and grant.

Suppose that the following parameters are given,

$s = (Y^p - C^p)/Y^p$: the average propensity to save in the private sector,

$\tau^d = T^d/Y$: the ratio of direct tax to income,

$\tau^i = T^i/Y$: the ratio of indirect tax to income,

$\mu = M/Y$: the average propensity to import,

$v = (C^g + I^g)/Y^g$: the ratio of government expenditure to disposable government income,

$\gamma = I^g/(C^g + I^g)$: the ratio of government investment to government expenditure

$s' = (Y^g - C^g)/Y^g$: the average propensity to save in the government sector,

$\frac{1}{\sigma} = \frac{I^p(t) + I^g(t)}{Y(t+1) - Y(t)}$: the marginal capital-output ratio.

By definition.

$$s' = 1 - (1 - \gamma)v \quad (4.1)$$

$$\tau = \tau^i + \tau^d \quad (4.2)$$

Denoting

$$\left\{ Y(t+1) - Y(t) \right\} / Y(t) = \Delta Y/Y = g, \quad (4.3)$$

we get the following Fundamental Equation of Economic Growth:

$$g = \sigma s (1 - \tau^d) + \sigma \left\{ 1 - (1 - \gamma)v \right\} (\tau^d + \tau^i) + \sigma \left(\mu - \frac{E}{Y} \right) \quad (5.1)$$

$$g = \sigma s (1 - \tau^d) + \sigma s' \tau + \sigma \left(\mu - \frac{E}{Y} \right), \quad (5.2)$$

or

$$g = \sigma s + \sigma \left\{ (s' - s) \tau^d + s' \tau^i \right\} + \sigma \left(\mu - \frac{E}{Y} \right) \quad (5.3)$$

It should be clear from equations (5.1) and (5.2) that the first term indicates the contribution of the investment financed by private savings; the second term the one by the government savings and the third term the one by the foreign loans or grants. If, therefore, foreign loans are not available to equalize imports to exports, then the last term drops off. If the government finances all its investment by deficit spending, then

$s' = 0$ so that the second term disappears. (In the case of a balanced budget, $I = v$ and the second term is $\sigma\gamma\tau = \frac{\sigma I^a}{Y}$, which indicates the contribution of I^a to generate the increased national output. Equation (5.3) clearly shows that the taxation transferring the purchasing power from the private to the public sector by direct taxes increases the rate of growth only in the case of $s' > s^a$. Now it would be obvious that the estimate of the growth rate of national income by $\sigma s (1 - \tau^a)$ implies no foreign assistance and no government savings.

Target-setting

Having established the Fundamental Equation of Economic Growth, we now proceed to set a target for economic growth of a national economy. The basic relations which we may use for target-setting are the following two definitional equations.

$$Y = \alpha P \dots\dots\dots (6.1)$$

$$Y = \rho N, \dots\dots\dots (6.2)$$

where

- P : Total population
- α : National income per capita or the standard of living
- N : Active labour force
- ρ : Average productivity of labour

A tentative fixed target may be set in terms of growth in Real National Income in one of the following two ways:

- (i) Estimate the future population (P_T) and the required standard of living in terms of Real National Income per capita (α_T). Comparing them with their present values (P_0, α_0), we could compute the required rate of growth in Real National Income (G); namely,

$$\alpha_0 P_0 (1 + G_T) = \alpha_T P_T \dots\dots\dots (7.1)$$

G_T gives us the growth rate over T years. The average annual rate g is given by

$$(1 + G_T) = (1 + g)^T \dots\dots\dots (7.2)$$

If the year to year rate of growth is needed, then ($P_1, P_2, \dots, P_T$) and ($\alpha_1, \alpha_2, \dots, \alpha_T$) should be given. Then we can compute

$$\alpha_{t-1} P_{t-1} (1 + g_{t-1}) = \alpha_t P_t, (t = 1, \dots, T) \dots\dots (7.3)$$

^a The effect of indirect taxes must be examined more carefully.

To simplify the following argument, we will take up the average annual rate of growth. It is clear that if

$$\alpha_t = \alpha_0 (1 + g_\alpha)^t; \dots\dots\dots (8.1)$$

$$\text{and } P_t = P_0 (1 + g_p)^t; \dots\dots\dots (8.2)$$

$$\text{then } g = g_\alpha + g_p + g_\alpha g_p \dots\dots\dots (8.3)$$

- (ii) Estimate the future population and the percentage of the active labour force to get the future strength of the labour force. Then set the required percentage of workers to be employed in the labour force. Then we know the required level of employment at the end of the planned period; that is, N_T . This is another way of setting a target in terms of employment rather than Y .

It is important and useful, however, to translate this target in terms of Y . For this purpose we have to estimate the average productivity of labour in the future either by extrapolating its past trend or by estimating some functional relation between the average productivity and the level of Y ; e.g.,

$$\rho = \bar{\beta} Y^\beta \dots\dots\dots (9.1)$$

$$\text{or } \rho = \beta' Y + \bar{\beta}' \dots\dots\dots (9.2)$$

This function is called "progress function or learning curve".^b Given this function we can calculate the level of Y corresponding to the required level of employment. We can get the required level of Y as

$$Y_T = \rho_T N_T = \bar{\beta} Y_T^\beta N_T$$

$$\therefore Y_T^{(1-\beta)} = \bar{\beta} N_T$$

$$\therefore \log Y_T = \frac{1}{1-\beta} (\log \bar{\beta} + \log N_T), \dots\dots (10.1)$$

$$Y_T = \frac{\bar{\beta}'}{1-\beta' N_T} N_T \dots\dots\dots (10.2)$$

Given Y_T , we can calculate g_T in the way mentioned above. Whichever way of target-setting is adopted, the remaining one may be used for checking the target set.^c

^b W.Z. Hirsch, "Manufacturing Progress Function", *R.E. Statis.*, (May 1952); "Firm Progress Ratios", *Econometrica*, (April, 1956); P.J. Verdoorn, "Complementarity and Long-Range Projections", *Econometrica*, (October 1956). For Japan, the author's estimate is $\rho = 0.144 Y + 4386$ where $\rho = Y/N$ (units Y : billion Yen, N : thousand).

^c Here we do not make any distinction between employment in industry and total employment. Only for the simplicity of exposition, we neglect the wage payments of Household, Government and the income and gifts from abroad.

Limits to parameters

In order to achieve a certain rate of growth set by the target in this way, those parameters and E involved in equations (5.1), (5.2) or (5.3) must add up to g set by the target. Our problem is, therefore, to find the optimum configuration of these variables, while taking into account the probable values of those when no deliberate policies are imposed upon them. Let us illustrate the kind of consideration we have to make in finding this optimum set of parameters. For instance, we may be able to estimate a saving function on the basis of the past time series; namely, $S = s'' Y^p + \bar{s}$. Then we do the following adjustment. From this equation we know

$$S = s'' (1 - \tau^d) Y + s \dots\dots\dots (11.1)$$

$$\therefore \frac{S}{Y} = s'' (1 - \tau^d) + \frac{\bar{s}}{Y} \dots\dots\dots (11.2)$$

This is the actual saving ratio. There are two ways of considering the possibilities of changing saving ratios; one is by changing the tax system τ^d , another by imposing a shift of the propensity to save. The latter aspect may be indicated by

$$s = \lambda_s \left\{ s'' (1 - \tau^d) + \frac{\bar{s}}{Y} \right\} \dots\dots\dots (12)$$

If $\lambda > 1$, it means that some deliberate policies are taken to cut down consumption. Needless to say, there is a limit to the extent of such policies. If this limitation should be taken into account, then we could state the condition as

$$s \leq \bar{\lambda}_s \left\{ s'' (1 - \tau^d) + \frac{\bar{s}}{Y} \right\} \dots\dots\dots (13)$$

where $\bar{\lambda}_s$ is the maximum of the possible change. If, however, there is no intention to take the measures directly influencing the saving ratio, then we simply compute the most probable saving ratio from (11.1) by inserting the target value of Y into the equation and consider this not as an instrumental variable but a structural parameter which is given and not controlled by the decision-maker.

Similar consideration should be given to other variables. To indicate a few other examples, there would certainly be a limit to the amount of deficit spending so that γ cannot exceed unity too much. The limitation may be given by the absolute amount or by some ratio, say,

$$\gamma \leq 1.2 \dots\dots\dots (14)$$

If B is a maximum deficit of foreign exchange determined by the possible foreign loans or the existing amount of foreign exchange reserve, then $M - E$ cannot exceed this B :

$$M \leq E + B \quad (15)$$

If B and E are given, this sets a limit to the amount of imports. Given the import function estimated on the past experiences of the economy, this may require some restrictions on imports. Then we should consider in a similar way as we did for savings, *i.e.*,

$$M = \mu' Y + \bar{\mu} \quad (16)$$

$$\lambda_m (\mu' Y + \bar{\mu}) \leq E + B, \quad (17)$$

where (16) is the import function and λ_m shows the degree of import restrictions. Y being set by our target, λ_m may be calculated for given E and B . Then it may turn out that λ_m is far below unity. Since there is a limit to import restrictions, it may be necessary to reconsider our tentative target unless a large scale of import substitution by domestic industries can take place. Another restriction which may be considered within the framework of our model here is the degree of taxation on national income. There seems to be a limit to the proportion of tax payment to income. Denoting its maximum by $\bar{\tau}$, this restriction may be expressed by

$$\tau \leq \bar{\tau} \quad (18)$$

With these limitational conditions in mind, we must find an optimum set of parameters which can attain the target. If none of these conditions is effective, then we may well consider raising our target further. If, however, our target cannot be attained by the values of parameters within the limitations imposed by (13), (14), (15), and (18), then we are forced to lower our target. In between these two extreme cases we have some degree of freedom in choosing the values of parameters. This decision may be made on the basis of further consideration on the desirability of changing the limits which we imposed to our parameters.

Appendix to chapter III

TWO AND THREE SECTOR MODELS

By

SHINICHI ICHIMURA

Two-sector models

The next stage of development programming is to subdivide the over-all plan expressed in terms of national income and related aggregates into sectoral plans. In practice, however, the shortage of statistical data, experienced staff for planning and time to complete a plan often makes it necessary to limit the number of sectors to a few main ones. In order to simplify the exposition and point out some important considerations, we first confine ourselves to simple two-sector models and then offer a three-sector model which may be of some use in practical applications. The order of models is chosen simply for convenience of exposition.

Consumption goods vs. capital goods sectors

Let us assume a closed economy for the moment which consists of the two sectors mentioned above. If it were possible to find a way of integrating various industries into these two sectors separately so that the intersectoral transactions might be neglected, then an extremely simple model could be constructed in this case.^a Using the following symbols:

X_i : the i -th sector's output

b_i : the i -th sector's capital-output ratio,

we have

$$\begin{cases} X_1 = (1-s)(X_1 + X_2) & \dots\dots\dots (1) \\ X_2 = b_1 \Delta X_1 + b_2 \Delta X_2 & \dots\dots\dots (2) \end{cases}$$

where the first sector is the consumption goods sector and the second the capital goods sector. Since all the intersectoral input-output relations are submerged into each sector, the national income of this economy is equal

^a A bi-sector model of P.C. Mahalanobis is exactly of this type.

to $X_1 + X_2$. Equation (1) clearly shows that the production of each sector must keep a definite proportion to each other. From (1) and (2), we get

$$\frac{\Delta X_2}{X_2} = \frac{s}{b_1(1-s) + s b_2} \dots\dots\dots (3)$$

If s does not depend on income, then the rate of growth does not differ from one sector to another.^b The growth rate of national income is also the same. Notice in (3) that in comparison with the simple Harrod-Domar Model in which $g = s/b$, the capital output ratio here is a weighted average of two sectors' capital-output ratios, and that the weight for b_1 is $(1-s)$: the propensity to consume and that for b_2 is s : the propensity to save:

$$b = (1-s) b_1 + s b_2 \dots\dots\dots (4)$$

The national capital output ratio is no longer a constant. If b_2 is larger than b_1 , the increase in s will make b larger and thereby accentuate its effect on the rate of growth g . Now note that in this model s may be taken from the decision made in the model discussed in Appendix to Chapter II, and capital goods must be allocated in such a proportion determined by sectoral capital output ratios, b_1 and b_2 .

Export vs. home-market sectors

Let us suppose next that the economy consist of two sectors, one of which is completely specialized in the production of export commodities. Using the same symbols and still neglecting the intersectoral input-output relations, we have the following equations:

$$X_1 = E(t) \dots\dots\dots (5)$$

$$M + X_2 = (1-s)(X_1 + X_2) + b_1 \Delta X_1 + b_2 \Delta X_2 \dots\dots\dots (6)$$

$$M = m_2 X_2 \dots\dots\dots (7)$$

where the first is the export sector, and the second is the domestic industry sector. It is assumed here that imports M depends on X_2 only. Export $E(t)$ would depend, among others, on the world income, export prices relative to competing prices and so on. On the basis of the projection of these variables, $E(t)$ may be projected for the planning period. Let us assume that these projected exports can be approximated by

$$E(t) = E_0 (1 + \varepsilon)^t, \dots\dots\dots (8)$$

^b If the saving function is $S = s(X_1 + X_2) - \bar{s}$, then the growth rate of X_2 is the same, but that of X_1 becomes slightly smaller than the former. The latter will approach, to the former as the absolute level of X_2 becomes larger.

where E_0 is the amount of exports in the base year, and ε is the growth rate of exports. Substituting this into (5), (6) and (7), we get

$$-b_2 X_2(t+1) + (m_2 + s + b_2) X_2(t) = (1 - s + b_1 \varepsilon) E_0 (1 + \varepsilon)^t \dots \dots \dots (9)$$

The solution of this difference equation is given by

$$X_2(t) = A \left(1 + \frac{m_2 + s}{b_2}\right)^t + B (1 + \varepsilon)^t \dots \dots \dots (10)$$

where

$$A = (X_2(0) - \frac{1 - s + b_1 \varepsilon}{m_2 + s - b_2 \varepsilon} E_0)$$

$$B = \frac{1 - s + b_1 \varepsilon}{m_2 + s - b_2 \varepsilon} E_0$$

This solution shows that even the domestic industry sector is influenced by the expansion of exports. If the rate of growth in exports is larger than the own rate of growth in the domestic industry sector; $\varepsilon > (m_2 + s)/b_2$, then the domestic industry's growth rate will be governed by ε eventually. If, however, $\varepsilon < (m_2 + s)/b_2$, then the growth rate of domestic industry will exceed that of the export sector sooner or later, and the economy can generate its own growth without awaiting the growth of exports. In this case, however, imports tend to exceed exports. To avoid this unfavourable balance of trade, m_2 must keep falling. This means that the import substitution by domestic industry must steadily continue. If this does not happen, then the economy cannot grow any faster than exports.^c

Notice that the own rate of growth of domestic industry sector is not influenced by the capital-output ratio of export sector but solely by its own capital-output ratio and $m_2 + s$. It is important to remember that in this model the division of capital goods between the two is not very simple. The distribution ratio changes from year to year.

Farm versus industrial sectors

Let us proceed then to the more important division of the economy into two sectors: Farm and Industrial Sector. This division requires not only the demarcation of productive activities but also that of households belonging to each sector. Still ignoring intersectoral relations and taking the first sector as the Farm or Agriculture Sector, we have the following equations:

$$X_1 = c_{11} X_1 + c_{12} X_2 \dots \dots \dots (11)$$

$$X_2 = c_{21} X_1 + c_{22} X_2 + b_1 \Delta X_1 + b_2 \Delta X_2 \dots \dots \dots (12)$$

^c If the average propensity to import rises as the level of production goes up, then the industrial rate of growth will be short of the growth rate of exports.

where c_{ij} denotes the j -th sector's propensity to consume the i -th sector's output. Here it is assumed that the output of the farm sector is not invested.

Since, unlike the previous models, this model assumes different consumption patterns in the two sectors it is appropriate to define not only the over-all saving ratio, but the sectoral saving ratio; for the farm sector and the industrial sector respectively,

$$s_1 = 1 - c_{11} - c_{21} \quad \dots\dots\dots (13)$$

$$s_2 = 1 - c_{12} - c_{22} \quad \dots\dots\dots (14)$$

Furthermore, c_{ij} must be specified in addition to b_1 and b_2 .

It will be of interest to notice from (11), (12), (13) and (14) that

$$s_1 X_1 + s_2 X_2 = b_1 \Delta X_1 + b_2 \Delta X_2, \quad \dots\dots\dots (15)$$

which shows savings = investment.

From these equations, we can get

$$\begin{aligned} \frac{\Delta X_2}{X_2} &= \frac{\begin{vmatrix} 1-c_{11} & -c_{12} \\ -c_{21} & 1-c_{22} \end{vmatrix}}{\begin{vmatrix} 1-c_{11} & -c_{12} \\ b_1 & b_2 \end{vmatrix}} = \frac{\begin{vmatrix} 1-c_{11} & -c_{12} \\ s_1 & s_2 \end{vmatrix}}{\begin{vmatrix} 1-c_{11} & -c_{12} \\ b_1 & b_2 \end{vmatrix}} \\ &= \frac{(1-c_{11})s_2 + c_{12}s_1}{(1-c_{11})b_2 + c_{12}b_1} \quad \dots\dots\dots (16) \end{aligned}$$

This equation shows that in this model the growth rate of the industrial sector may be calculated by dividing the weighted average of saving ratios by the weighted average of capital-output ratios. The weights are the proportions of demand for the opposite sector.

This equation (16) clearly indicates how the growth rate of the industrial sector is determined by various sectors. An implicit assumption here is that equation (11) is always satisfied; that is to say, agricultural production can always be expanded to catch up with industrial production. Without this corresponding increase in X_1 , industrial production can never attain its potential own rate of growth, given by (16). It will be pressed down to the rate set by the maximum rate of growth in agricultural production unless the balance may be imported.

Farm versus industrial sectors with foreign trade

In order to consider a more realistic case, let us suppose that both sectors export and import. Then our system of equations would be as follows:

$$X_1 + M_1 = c_{11}X_1 + c_{12}X_2 + E_1 \dots\dots\dots (17)$$

$$X_2 + M_2 = c_{21}X_1 + c_{22}X_2 + b_1 \Delta X_1 + b_2 \Delta X_2 + E_2 \dots (18)$$

$$M_1 + M_2 \leq E_1 + E_2 + B \dots\dots\dots (19)$$

This system can be used for the solution of different policy problems. Suppose that $E_1(t)$, $E_2(t)$, $B(t)$ and $X_1(t)$ are given by projection. What would be the maximum rate of growth in industrial production? The practical way of finding it would be first to take the capacity level of X_2 and then by (17) to determine M_1 . Substituting M_1 into (19) and equalizing both sides, we obtain M_2 and then by (18) we can determine ΔX_2 , which gives the capacity level of $X_2(t+1)$. By repeating the same procedure, we can determine the time-path of $X_2(t)$.

If, however, the production of the farm sector can be expanded as fast as demand increases, then M_1 may be set equal to zero. Then (17) gives a certain relation between X_1 and X_2 as well as E_1 . Substitute (17) and M_2 given by (19) into (18), and we have a difference equation very similar to equation (9) on p.89 above, which can be solved in the same way.

Before proceeding any further to complicate the model, we shall show a way of applying these models for development programming.

Target-setting for two-sector model

As an example let us formulate a way of setting a target for farm versus industrial sectors model. It is useful for the following arguments to distinguish between the supply of labour in each sector and the demand for labour which is technically determined by the level of production in each sector. Denoting the former by N_i^s and the latter by N_i^d , we may assume that

$$N_1^s(t) = N_1^s(o) (1 + g_1)^t \dots\dots\dots (20)$$

$$N_2^s(t) = N_2^s(o) (1 + g_2)^t \dots\dots\dots (21)$$

Generally, $g_1 > g_2$ and $N_1(o) > N_2(o)$

$$N_1^d(t) = f_1[X_1(t)] \dots\dots\dots (22)$$

$$N_2^d(t) = f_2[X_2(t)] \dots\dots\dots (23)$$

The disguised unemployment in the farm sector may be expressed by $(N_1^s - N_1^a)$. Then a target of development programming may be set so as to absorb as many farmers as possible in the industrial sector. If, for instance, the disguised unemployment is to be extracted from the farm sector, then the employment in the industrial sector must increase as

$$N_2^a(t) = N_1^s(t) + N_2^s(t) - N_1^a(t) \dots\dots\dots (24)$$

It is clear from (23) that if $f_2' > 0$, as it should be, more workers will be needed only when more is produced in the industrial sector. Hence, the problem of achieving the target is to maximize $X_2(t)$ subject to the conditions set by equations (17), (18) and (19). This is exactly what we discussed in the previous section. Since $X_1 + X_2 =$ national income, the general rate of development discussed in Appendix to Chapter II may be re-examined in the light of the considerations here.

Now note that in these models the choice of capital allocation does not appear in an essential way. The criterion for achieving the maximum rate of industrialization is to make the full use of existing capital stock; try to save as much as the public could spare; and keep the balance between the supply and the demand in the farm sector.

Three sector model

(i) In the Balance Equations so far we have confined ourselves to special types of two-sector models and ignored the intersectoral relations. This was necessary in order to avoid needless complications in exposition. Now we are in a position to discuss more complicated models.

If we have two or more capital goods industries in our model, then an entirely new problem of choice in investment decisions emerges in development programming. Since the strict distinction between consumption goods industry and capital goods industry can hardly be applicable to any concrete industries, we may perhaps more appropriately assume that the two industries are those whose outputs can be used both for consumption and for investment. Let us then suppose that there are three sectors in the economy: (1) agriculture, (2) industry I, (3) industry II.

The balance equations of this model are:

$$X_1 = a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + c_{11}y_1 + c_{12}y_2 \dots\dots\dots (25.1)$$

$$X_2 = a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + c_{21}y_1 + c_{22}y_2 + \Delta K_2 \dots\dots\dots (25.2)$$

$$X_3 = a_{31}X_1 + a_{32}X_2 + a_{33}X_3 + c_{31}y_1 + c_{32}y_2 + \Delta K_3 \dots\dots\dots (25.3)$$

$$y_1 = a_{41}X_1 \dots\dots\dots (25.4)$$

$$y_2 = a_{42}X_2 + a_{43}X_3 \quad \dots\dots\dots (25.5)$$

$$K_2 \geq b_{21}X_1 + b_{22}X_2 + b_{23}X_3 \quad \dots\dots\dots (25.6)$$

$$K_3 \geq b_{31}X_1 + b_{32}X_2 + b_{33}X_3, \quad \dots\dots\dots (25.7)$$

where

X_i = the level of production in the i -th sector

y_i = the income accruing to the i -th sector

N_i = the level of labour employment in the i -th sector

a_{ij} = the amount of the i -th sector's output used to produce one unit of the j -th sector's output ($i = 1, 2, 3; j = 1, 2, 3$)

a_{4j} = the ratio of factor payments to the level of production in the j -th sector ($j = 1, 2, 3$)

b_{ij} = the intersectoral capital-output ratio of the j -th sector for the i -th sector's output

c_{ij} = the j -th sector's average propensity to consume the i -th sector's output

K_i = the stocks of capital goods of the type i .

(ii) *Reduction to two-sector model*

Before proceeding any further in the formulation of our problem, we will show that this three-sector model could be reduced to a two-sector model. From (25.1) — (25.5) we have:

$$\left\{ \begin{array}{l} (1 - a_{11} - c_{11}a_{41})X_1 - (a_{12} + c_{12}a_{42})X_2 - (a_{13} + c_{13}a_{43})X_3 = 0 \\ - (a_{21} + c_{21}a_{41})X_1 + (1 - a_{22} - c_{22}a_{42})X_2 - (a_{23} + c_{23}a_{43})X_3 = \Delta K_2 \\ - (a_{31} - c_{31}a_{41})X_1 - (a_{32} + c_{32}a_{42})X_2 + (1 - a_{33} - c_{33}a_{43})X_3 = \Delta K_3 \end{array} \right. \quad \dots\dots (26)$$

By denoting

U = a determinant consisting of the elements of (26)

U_{ij} = cofactor of (ij) element in matrix U ,

$$\frac{U_{ij}}{U} = A_{ij}$$

$$\left\{ \begin{array}{l} X_1 = A_{21} \Delta K_2 + A_{31} \Delta K_3 \\ X_2 = A_{22} \Delta K_2 + A_{32} \Delta K_3 \\ X_3 = A_{23} \Delta K_2 + A_{33} \Delta K_3 \end{array} \right. \quad \dots\dots\dots (27)$$

By substituting (27) into (25.6) and (25.7), we get

$$\begin{aligned} K_2 &\geq (b_{21}A_{21} + b_{22}A_{22} + b_{23}A_{23}) \Delta K_2 \\ &\quad + (b_{21}A_{31} + b_{22}A_{32} + b_{23}A_{33}) \Delta K_3 \\ K_3 &\geq (b_{31}A_{21} + b_{32}A_{22} + b_{33}A_{23}) \Delta K_2 \\ &\quad + (b_{31}A_{31} + b_{32}A_{32} + b_{33}A_{33}) \Delta K_3 \end{aligned} \quad \dots\dots (28.1)$$

which may be rewritten as

$$\begin{aligned} K_2 &\geq B_{22} \Delta K_2 + B_{23} \Delta K_3 \\ K_3 &\geq B_{32} \Delta K_2 + B_{33} \Delta K_3 \end{aligned} \quad \dots\dots\dots (28.2)$$

Now notice that U includes not only the technical input coefficients but also the consumption coefficients for the agriculture and industry sectors.

(iii) Efficient path of capital accumulation

So long as (28.2) is satisfied, there is no possibility of imbalance between demand and supply nor that of demand exceeding production. But this system of equations cannot necessarily determine the best way of capital accumulation. One might think that given $K_1(t)$ and $K_2(t)$ as initial conditions, (28.2) may be solved for $K_1(t+1)$ and $K_2(t+1)$ if inequalities are replaced by equalities.^a If this solution gives us the positive K_i 's, then it gives the full capacity rate of capital accumulation. But there may not be such a positive solution. Moreover, even if there is a solution, some other solutions may be preferable if at least one of $K_i(t+1)$'s is greater than the value of the full capacity solution. For the configuration of capital stocks at the beginning of period $(t+1)$ determines the possibilities of best menu for future consumption. Thus, depending on the desired pattern of future consumption, the desirable structure of capital will be different. Unless, therefore, the composition of capital stocks is given, the best process of capital accumulation cannot be determined. If, for instance, the ratio of $K_1(t+1)$ to $K_2(t+1)$ is given, then the problem is reduced to the one we discussed in previous sections.

Another neat way of treating this problem would be to attach some evaluation or weight to these two types of capital goods at a future date. If these relative weights are $p_1(t+1)$, $p_2(t+1)$, then our problem is: to maximize

$$p_1(t+1) \Delta K_1 + p_2(t+1) \Delta K_2, \dots\dots\dots (28.3)$$

^a Since our model has been reduced to a two sector model, the subscripts indicating the sectors are changed.

subject to (28.2). Then one could find the optimal path of capital accumulation. Clearly, this optimal path depends on the weights used in (28.3) so that, depending upon them, we have a set of optimal rates of capital accumulation of each capital stock. This set is called the efficient locus, and choice in investment decisions must be made on this "efficient locus" of capital accumulation. Note that this efficient locus is not always the one of full capacity of both capital stocks.

(iv) *Maximal rate of steady growth*

It is clear now that the problem is one of typical dynamic linear programmings. Although the above-mentioned argument was confined to capital accumulation in one year, it is quite possible to formulate the problem so as to find the optimal passage for a number of years to come. One example would be: to maximize

$$p_1 (t+2) \Delta K_1 (t+1) + p_2 (t+2) \Delta K_2 (t+1)$$

subject to

$$\begin{aligned} B_{11} \Delta K_1 (t) + B_{12} \Delta K_2 (t) &\leq K_1 (t) \\ B_{21} \Delta K_1 (t) + B_{22} \Delta K_2 (t) &\leq K_2 (t) \\ -\Delta K_1 (t) + B_{11} \Delta K_1 (t+1) + B_{12} \Delta K_2 (t+1) &\leq K_1 (t) \\ -\Delta K_2 (t) + B_{21} \Delta K_1 (t+1) + B_{22} \Delta K_2 (t+1) &\leq K_2 (t) \\ \Delta K_1 &> 0, \Delta K_2 > 0. \end{aligned}$$

The time-scope may be extended to a very long period.

In this linear programming problem, it is already proved that, for an appropriate set of initial stocks, there is one maximal steady rate of growth. In the above model, the path of capital accumulation corresponding to full capacity gives this maximal rate of steady advance which is faster than any other growth rate. Thus, the optimal path of capital accumulation would be plotted first on the basis of the best configuration of capital stocks at the end of planned period. In the early stage of planning the capital structure should be changed into that approaching to the maximal steady-growth proportion and in the later stage switched back to the desired terminal proportions. This is possible only for a sufficiently long period. Moreover, this path exists only when the economy of scale does not play its role or the economy is closed, and the initial stocks of K_1 and K_2 may be very far removed from the appropriate ones. In practical programming, these complications and many others must be taken into consideration.*

* Cf. Dorfman, Samuelson and Solow, *Linear Programming and Economic Analysis*, chapters 11 and 12; E. Malinvaud, "Capital Accumulation and Efficient Allocation of Resources", *Econometrica*, (April, 1953).

Appendix to chapter V
DYNAMIC INPUT-OUTPUT AND LINEAR
PROGRAMMING MODELS

By

SHINICHI ICHIMURA

Static input-output analysis

A static input-output table may be expressed as:

$$X_i - \sum a_{ij} X_j = f_i \quad \dots\dots\dots (1.1)$$

$$M' - \sum a_{mj} X_j = 0 \quad \dots\dots\dots (1.2)$$

$$y - \sum a_{vj} X_j = f_v \quad \dots\dots\dots (1.3)$$

where

- f_i : the final bill of goods for sector i
- M' : the total amount of non-competitive imports
- a_{mj} : the amount of non competitive imports per unit of X_j
- y : the total of value added accruing to each sector
- a_{vj} : the rate of value added per unit of X_j
- f_v : the final bill of goods for the household sector

The final bill of goods is usually divided into the following sub-groups:

- Household Consumption (C_i), Government Consumption (C_g),
- Fixed Capital Formation (I_i), Net Increase in Inventories (I_i),
- Exports (E_i), and Competitive Imports (M_i) (treated as minus items).^a

^aThe distinction between "competitive" and "non-competitive" imports is made according as there is any domestic production of similar products. If, however, the proportion of domestic production to imports is very low, it may be more appropriate to treat such imports as non-competitive imports. In that case, the inputs required by the domestic production must be treated separately. One way would be to estimate the total amount of domestic production of each product on a separate basis and calculate the input requirements by applying the input coefficients and then regard them as a part of final demands.

Thus,

$$f_i = C_i + C_i^s + I_i + J_i + E_i - M_i \dots\dots\dots (1.4)$$

If we denote a unit matrix by e , matrix (a_{ij}) by a , and column vectors (x_i) and (f_i) by x and f , then x can be solved for given f :

$$(e - a) x = f \dots\dots\dots (2.1)$$

$$\therefore x = (e - a)^{-1} f \dots\dots\dots (2.2)$$

To specify the values of (f_i) , we must have some method of fixing the values of each component of (f_i) shown in (1.4).

A combination of input-output model with macro-models

One of the typical and straightforward applications of static input-output analysis to development programming is to compute the level of production in each sector on the basis of the values of aggregate variables estimated by macro-models. Those aggregate variables include National Income, Imports, Exports, Savings, Consumptions, Government Expenditure and Investment in fixed capital and inventories. Then the problem is how to decompose them into the more detailed break-downs of an input-output model. There are many conceivable ways of doing this.^b Here we shall discuss merely one of many possibilities. In practice, however, it is important to try out various methods and by checking the results to reach the most appropriate disaggregation.

The following method hardly needs any explanation. The symbols with no suffix stand for the aggregate variables which are already known from our macro-models.

Household consumption may be regarded as a linear function of total consumption C ; namely,

$$C_i = \alpha_i C + \bar{\alpha}_i \dots\dots\dots (3.1)$$

Clearly,

$$\sum \alpha_i = 1 \dots\dots\dots (3.2)$$

$$\sum \bar{\alpha}_i = 0 \therefore \dots\dots\dots (3.3)$$

If the aggregate consumption function is already known, and the income elasticities of each type of output is calculated, then the estimates of C_i by this method can be obtained with the aid of (3.1).

^b Cf. J. Sandee & D.B.J. Schouten, "A Combination of a Macro-Economic Model and a Detailed Input-Output System", in *Input-Output Relations*, Netherlands Economic Institute, Leiden 1953. R. Frisch, *The Oslo Decision Model*, (mimeographed) Oslo, 1958.

The disaggregation of government expenditure into C_i^g may be made in two steps; first, by dividing the total expenditure into government consumption C^g and investment I^g ; and second, by distributing the government consumption to C_i^g . Given these distribution proportions g_i , we may express:

$$C_i^g = g_i C^g = g_i \alpha^g G, \quad \dots \quad (4.1)$$

where G stands for total government expenditure, and α^g the consumption ratio to G . Needless to say,

$$\sum g_i = 1 \quad \dots \quad (4.2)$$

As for exports, if the estimate of future exports is based on the detailed studies of export commodities, then the disaggregation is a matter of summation into smaller sub-groups. Otherwise, however, some additional research will be needed to disaggregate the total amount of exports. Such research will consist of the extrapolation of past trends of commodity exports or the estimate of export demand functions and the expected values of foreign incomes, populations and the export prices.

The usual way of treating competitive imports is to assume a constant ratio between M_i and X_i :

$$M_i = m_i X_i \quad \dots \quad (5.1)$$

Sometimes this ratio may be changed from the view-point of substituting domestic production for imports.^c From the analytical point of view, however, it is not at all necessary to assume this type of relations. M_i may very well be related to any variables in the system; e.g. C_i , a_{ij} , X_j , or sectoral investment.

If (5.1) is assumed, then M_i becomes an endogenous variable. And X may be solved in the following way:

$$X = (e + m - a)^{-1} f \quad \dots \quad (5.2)$$

Here m is a diagonal matrix, whose diagonal elements are (m_i) , and f no longer contains competitive imports. If, however, some M_i 's are related to exogenous variables, then those M_i 's will be exogenous too.

Given E_i and M_i , we can and must check them with the predetermined values of E and M by summing up E_i and M_i . As a result, some alterations of macro figures will be necessary until we get

$$E = \sum E_i \quad \dots \quad (6.1)$$

$$M = \sum M_i + M^p \quad \dots \quad (6.2)$$

^c See the argument on Linear Programming Models in a following section of this appendix.

Notice here that the total of non-competitive imports M' is added to $\sum M_i$. If we have some maximum allowance for unfavourable balance of trade B , then it must be checked so that the balance may not exceed this B .

$$B \geq M - E \quad \dots\dots\dots (6.3)$$

Finally, the most difficult break-down is that of investment. One way of fixing I_i and J_i would be the following. Since

$$y - C = I + J - D \quad \dots\dots\dots (7.1)$$

and y , C and D are supposed to be given by macro-models, we know the total of $I + J$. Then, dividing this total into I and J by assuming some proportional divisions between the two, we have only to disaggregate I into I_i by extrapolating, for example, the past trend in the composition of I_i :

$$\frac{I_i}{I} = i t + \bar{i} \quad \dots\dots\dots (7.2)$$

As for J_i , however, rather than proceeding in the same way, we may assume

$$J_i = \gamma_i (X_i + M_i), \quad \dots\dots\dots (7.3)$$

which means that, if the values of J_i , X_i and M_i are measured as the increments above the levels in the base year, the inventory holdings are proportional to the sales of that commodity.

Given (7.3),

$$[(e + m)(e - \gamma) - a] X = f \quad \dots\dots\dots (7.4)$$

$$\therefore X = [(e + m)(e - \gamma) - a]^{-1} f \quad \dots\dots\dots (7.5)$$

If, however, the "sectoral capital-output ratios" b_i are known, then the total amount of capital needed to produce X_i can be calculated by $\sum b_i X_i$. Subtracting the existing amount of capital from this total, we get the amount of investment required to generate the capacity to produce X_i . This total may be compared with our assigned value of $I + J$. If both do not coincide, then some adjustments of the composition of I_i or in saving or income may be necessary.

After assigning all the values of f_i 's, we can calculate the level of national expenditure y or the national income at market value. Obviously,

$$\sum_i a_{ij} + a_{mj} + a_{yj} = I, \quad \dots\dots\dots (8.1)$$

$$\text{and } y = \sum f_i - M, \quad \dots\dots\dots (8.2)$$

which is merely an expression of

$$\text{National Income Received} = \text{National Expenditure.}^d$$

If, moreover, the government revenues can be related to X_i in each sector, it is possible to estimate the future budget of government account. In this way, all the variables in macro-models may be re-examined by the input-output model. This re-examination will certainly lead to the higher degree of reliability in macro-figures, not to mention the additional information obtained about the details of our economic plans.

The problem of employment

Sometimes it is assumed that the number of workers (men-years) employed in each sector is proportional to the level of production of that sector:

$$N = \sum n_i X_i, \dots\dots\dots (9.1)$$

where n_i is the i -th sector's labour-output ratio. Since, however, the labour productivity in the real world rises steadily as the level of production goes up, it is important for development programming to take into account this relationship. In general we may express it as:

$$N_i = f_i(X_i), \dots\dots\dots (9.2)$$

and

$$N = \sum N_i = \sum f_i(X_i) \dots\dots\dots (9.3)$$

The so-called learning functions are only the special cases of $f_i(X_i)$.^e

If the empirical forms of (9.2) are given, then a certain level of employment N will be associated with a given final bill of goods and hence with the level of national income. In macro-models we have been assuming a certain functional relationship between N and y or similar relations in Farm and Industrial Sectors and other aggregative sectors. These relations may be re-examined in the light of this more detailed analysis of inter-industrial relations.

^d Not that C_y^g and C_y are not zero but represent the tax payments.

^e If $\frac{X_i}{N_i} = a_i X_i^{b_i}$, $N_i = \frac{1}{a_i} X_i^{1-b_i}$

If $\frac{X_i}{N_i} = a_i X_i + b_i$, $N_i = \frac{X_i}{a_i X_i + b_i}$

Variable input coefficients

So far we have assumed that the input coefficients are technically given and remain unchanged throughout the planning period. They may change in reality, for instance, if different techniques are adopted or if economies of scale prevail. This does not necessarily, however, invalidate the whole argument above, based on the assumption of constant input coefficients. In many cases, the technical input coefficients to be used after ten years or so can be estimated with a fair degree of assurance. Then those future coefficients may be used to calculate the pattern of industrial production in a future year.

In some cases, the coefficients a_{ij} may change as X_j change. Then a linear approximation will provide us with better information than a proportionate relation; namely,

$$X_{ij} = a_{ij}X_j - \bar{a}_{ij} \quad \dots\dots\dots (10.1)$$

where X_{ij} is the input of the i -th sector's output to the j -th sector. It is unlikely, however, for the input coefficients of material requirements to change very much. The variable coefficients are mostly those connected with transportation, services, labour, or capital. There may be some cases such as agriculture, mining and fishery in which the levels of production can be estimated better by some other econometric models. These industries may be separated from the main body of input-output system and incorporated with it in the special way.

Whenever the changes in input coefficients are taken into account, it is very important to remember the following relation which must be satisfied by any sector's inputs and outputs:

$$\sum_i X_{ij} + M_j' + \gamma_j = X_j, \quad \dots\dots\dots (10.2)$$

where M_j' is the non-competitive imports of the j -th sector, and γ_j the value added by the same sector. This implies that a change in one coefficient may be compensated by the change in some other coefficients.

Capital coefficients

The static input-output system becomes dynamic when the capacity-creating effect of investment is taken into account. As we have discussed previously, the sectoral capital-output ratios are defined by¹

$$b_j = \frac{K_j'}{X_j} \quad \dots\dots\dots (11.1)$$

¹Notice here that K_j' stands for the capital stocks held by the j -th sector. Previously we used the notation ΔK_i which means the investment of the i -th sector's output. To avoid any confusion, I shall use I_i in the sense of ΔK_i in the previous arguments. K_j' here consists of many kinds of capital goods.

which may be rewritten as

$$K'_j = b_j X_j \dots\dots\dots (11.2)$$

For some sectors at least, however, K'_j may be linearly related to X_j :

$$K'_j = b_j X_j + \bar{b}_j \dots\dots\dots (11.3)$$

Now note that capital here may or may not include inventories as well as fixed capital. For the purpose of long-term development programming, it is more desirable to include inventories and estimate the relations between inventory holdings and X_j or $X_j + M_j$. If this proves to be difficult, then we may come back to our previous assumption (7.3). To simplify the following argument, we shall assume that our K'_j includes inventories as well as fixed capital.⁸

Needless to say, K'_j consists of various types of capital goods. Given this structure, we may assume the proportionate distribution of K'_j among those capital goods. Denoting the i -th sector's output (capital goods) held by the j -th sector by K_{ij} , we may express the composition of K'_j as:

$$K_{ij} = \beta_{ij} K'_j \dots\dots\dots (12.1)$$

Clearly,

$$\sum_i \beta_{ij} = 1, \dots\dots\dots (12.2)$$

and

$$K_{ij} = \beta_{ij} b_j X_j + \beta_{ij} \bar{b}_j \dots\dots\dots (12.3)$$

$$\therefore K_{ij} = b_{ij} X_j + \bar{b}_{ij} \dots\dots\dots (12.4)$$

where $b_{ij} = \beta_{ij} b_j$

$$\bar{b}_{ij} = \beta_{ij} \bar{b}_j$$

From (11.3) and (12.4), we get

$$\Delta K'_j = b_j \Delta X_j \dots\dots\dots (13.1)$$

$$\text{or } K'_j(t+1) - K'_j(t) = b_j [X_j(t+1) - X_j(t)] \dots\dots (13.2)$$

and

$$\Delta K_{ij} = b_{ij} \Delta X_j \dots\dots\dots (14.1)$$

or

$$I_{ij}(t) = b_{ij} [X_j(t+1) - X_j(t)] \dots\dots\dots (14.2)$$

⁸In practice the proportion of the inventories held to the total amount of final demand for the same sector is rather small, and in the long run it is unlikely to play a significant role in our model.

These b_{ij} 's may be called the "sub-sectoral capital coefficients".

It is clear that

$$\sum_j I_{ij} + \bar{I}_i = I_i \quad \dots\dots\dots (15.1)$$

and $\sum_j I_{ij} = \Delta K_i \quad \dots\dots\dots (15.2)$

where $\bar{I}_i$ represents the investment of the i -th sector's output which is independent of ΔX_i ; for instance, those by government and household. From the point of view of development programming, it may be desirable that the government should try to keep the parts of its investment in the "desirable proportions" to their related variables. For example, road construction may be kept in a certain proportional relation to the demand for transportation services. The same is true for housing. It may be related to national income or population or something else.

It should be kept in mind that the X_i 's in the function above represent the capacity level of production which is different from the actual level of production when there is some surplus capacity. It may be of some interest to notice here that, if the capital/output relations and the labour/output relations are given, then the capital/labour relations may be derived from them. Given (11.3) and (9.2),

$$\frac{K_i}{N_i} = \frac{b_i X_i + \bar{b}_i}{f_i(X_i)} \quad \dots\dots\dots (16.1)$$

If $N_i = A_i X_i^{1-\beta_i}$, $\bar{b}_i = 0$,

$$\frac{K_i}{N_i} = \frac{b_i}{A_i} X_i^{\beta_i} \quad \dots\dots\dots (16.2)$$

Another implicit assumption in (11.3) or (14.1) is that there is only one uniform time-lag between the time of investment and the time of the increase in capacity. This point will be discussed later.

Dynamic input-output system

Given the capital coefficients, a dynamic input-output system may be expressed by the following system of equations:

$$(1 + m_i) X_i - \sum_j a_{ij} X_j - I_i = C_i + C_i^g + E_i \quad \dots\dots\dots (17.1)$$

$$\sum_j b_{ij} X_j + \bar{b}_i \leq K_i \quad \dots\dots\dots (17.2)$$

In the real input-output relations, b_{ij} 's and $\bar{b}_{ij}$'s for some i may be all zero, even if capital includes inventories. In this case, for such i 's $K_i = 0$, $I_i = 0$. If, the system is operating at full capacity all the time, (17.2) may be written as

$$\sum b_{ij} X_j + \bar{b}_{ij} = K_i, \dots\dots\dots (17.3)$$

and (17.1) and (17.3) can be solved for given K_i , C_i , C_i^g and E_i^h . The time-path of $X_j(t)$ and $K_i(t)$ will be determined accordingly, if the future patterns of C_i , C_i^g and E_i are predetermined. Since I_i are given, $K_i(t+1)$ will be determined as $K_i(t+1) = K_i(t) + I_i(t)$.

It is of great importance, however, to notice that, as the future pattern of consumption and exports changes, there is no need to use all the capital equipment to the full. In fact, some types of capital may become completely unnecessary. Then the inequalities of (17.2) are at work. In this case, (17.1) and (17.2) may not give the solution to X_j and I_i for given C_i , C_i^g and E_i . In order, therefore, to determine the optimal path of capital accumulation, we must introduce some criterion for the choice of a particular combination of I_i among all the possibilities. This necessitates a reformulation of this problem in terms of linear programming model.

A linear programming formulation of dynamic input-output system

Let us consider the simplest case in which only one period is involved. On the assumption that all the goods are measured at the prices in the base year, and that there is no change in the prices and the relative importance of capital goods for the future pattern of consumption or exports, the most natural criterion for choosing the best capital accumulation would be to set such a target as to maximize the national income in that period. The national income Y is defined by

$$Y \equiv \sum C_i + \sum C_i^g + \sum I_i + \sum E_i - \sum M_i - M' \dots\dots\dots (18.1)$$

Since we assume that C_i 's, C_i^g 's and E_i 's are given, the maximization of Y amounts to the same as the maximization of $\sum I_i - \sum M_i - M'$.

Substituting (1.2), (5.1) into this, we have

$$\sum I_i - \sum m_i X_i - \sum a_{mj} X_j \dots\dots\dots (18.2)$$

Thus, our problem may be formulated as the one to maximize (18.2) subject to (17.1) and (17.2). In the matrix notation (17.1) is expressed as

$$(e + m - a) X = I + F, \dots\dots\dots (19.1)$$

ⁿ If there are nX_j 's and $m(\leq n)K_i$'s, then the number of equations is $(n+m)$ and unknowns are nX_j 's and mI_i 's.

where $F = \{C + C^g + E\}$. By denoting
 $(e + m - a)^{-1} = A$, (19.2)

we have

$$X = AI + AF \text{ (19.3)}$$

Hence, (17.2): $bX + \bar{b} \leq K$ may be expressed as

$$bAI + bAF + \bar{b} \leq K \text{ (19.4)}$$

so that if we put $B = bA$, we get

$$BI \leq K - BF - \bar{b} \text{ (19.5)}$$

Since (18.2) can be expressed as

$$I - [m + a_m] X, \text{ (19.6)}$$

where $m + a_m$ is a row vector and X is a column vector, it can be rewritten as

$$I - [m + a_m] \{AI + AF\} \text{ (18.3)}$$

As AF consists of constants, we may omit it from our maximand. Thus we have instead of (19.6),

$$[e - (m + a_m)] AI, \text{ (18.4)}$$

which is now to be maximized under the conditions of (19.5). (18.4) is the target function in this formulation. It states clearly that the more imports, direct and indirect, a certain type of investment requires, the less weight it gets in the target function. Thus this formulation implies that the investment plan is chosen so as to maximize national income with the least imports. By putting each element of a row vector $[e - (m + a_m)] A$ equal to v_i , we have

$$\sum v_i I_i \text{ (18.5)}$$

These v_i 's are the weights attached to each type of capital goods. For a given set of v_i 's one combination of I_i 's will be the optimum pattern of capital accumulation. For another set of v_i 's we have another solution of I_i 's. These are the "efficient paths" of capital accumulation.

Intertemporal efficiency

Let us proceed to a more practical case of development programming in which the time-scope of a plan certainly extends over more than a year.¹

¹One might think that a unit period in our formulation could be interpreted as any length of time. But this is not so, because, as the length of a unit period is extended, the capacity-creating effect of investment must work within the period. This point is not considered in the above arguments. See the following section.

Then the formulation becomes more complicated. First of all, the balance equation like (19.1) or (19.3) must be specified for each period:

$$BI_t \leq K_t - BF_t - \bar{b} \dots\dots\dots (20.1)$$

$$BI_{t+1} \leq K_{t+1} - BF_{t+1} - \bar{b} \dots\dots\dots (20.2)$$

Since $K_{t+1} = K_t + I_t$, (20.2) may be written as

$$-e I_t + BI_{t+1} \leq K_t - BF_{t+1} - \bar{b} \dots\dots\dots (20.3)$$

Thus the subsidiary conditions of our system are:

$$\begin{cases} BI_t & \leq K_t - \bar{b} - BF_t \\ -e I_t + BI_{t+1} & \leq K_t - \bar{b} - BF_{t+1} \end{cases} \dots\dots\dots (20.4)$$

The natural way of setting our target would be to maximize the national income at the end of our planning period. Then, that in period $t + 1$ is:

$$\begin{aligned} & F_{t+1} + I_{t+1} - [m + a_m] X_{t+1} \\ = & [e - (m + a_m)] I_{t+1} + [e - (m + a_m)] F_{t+1} \dots\dots (21.1) \end{aligned}$$

Since F_{t+1} is given on some other basis, we may delete it from our maximand and try to maximize

$$[e - (m + a_m)] I_{t+1} \dots\dots\dots (21.2)$$

subject to (20.4).^j The solution of this system gives the optimum pattern of I_t and thus defines the "intertemporal efficiency" for the optimum path of capital accumulation. Similar arguments apply to any length of period.

The gestation period in investment

In the foregoing argument, it has been assumed that the investment in one period does not add any capacity in the same period but does increase the capacity next period. In practice, however, the gestation period may be longer or even shorter. Particularly from the viewpoint of development programming, the long gestation period is very important, because it is the long-term investment that plays an important role in economic development.^k

^j G.B. Dantzig suggested a convenient method of solving this linear programming problem. Cf. "Upper Bounds, Secondary Constraints and Block Triangularity in Linear Programming", *Econometrica*, (April, 1955).

^k In this connexion, Hayek's distinction about intertemporal relations between input and output may be worth remembering; (1) Point-input and point-output case; (2) point-input and continuous-output case; (3) continuous-input and point-output case; and (4) continuous-input and continuous-output case.

As an important example, let us take the construction of a hydro-electric power station. Suppose an economy which consists of three industries and whose first industry is the electricity industry. Let us assume that the construction of a hydro-electric dam which takes two years is contemplated now. For the purpose of the following discussion, it is convenient to separate the capital stocks of the electricity industry from the other types of capital stocks and express it in terms of its generating-power. Then we may assume that the increase of its power by one unit requires the inputs $\delta_{21}(1)$, $\delta_{31}(1)$ in the first year and $\delta_{21}(2)$, $\delta_{31}(2)$ in the second year, and after two years one unit of generating power is increased. If, therefore, the increase of the generating power by $\Delta K'_1$ in the third year is planned, the required amounts of input for the first and second years are:

$$\delta_{21}(1) \Delta K'_1, \delta_{31}(1) \Delta K'_1 \text{ and } \delta_{21}(2) \Delta K'_1, \delta_{31}(2) \Delta K'_1$$

This $\Delta K'_1$ increases the capacity of the electricity industry at the beginning of the third year. As for the rest of capital stocks, we may simply follow the aforementioned treatment. For example, for the second industry in the first and second years we have:

$$X_2(1) - a_{21}X_1(1) - a_{22}X_2(1) - a_{23}X_3(1) - I_2(1) - \delta_{21}(1) \Delta K'_1 = F_2(1)$$

$$b_{21}X_1(1) - b_{22}X_2(1) - b_{23}X_3(1) \leq K_2(1) - \bar{b}_2$$

$$X_2(2) - a_{21}X_1(2) - a_{22}X_2(2) - a_{23}X_3(2) - I_2(2) - \delta_{21}(2) \Delta K'_1 = F_2(2)$$

$$b_{21}X_1(2) - b_{22}X_2(2) - b_{23}X_3(2) - I_2(2) \leq K_2(2) - \bar{b}_2$$

Notice here that what contribute to $K_2(2)$ is only the part of the investment of industry II's output which is outside of the construction of a hydroelectric dam so that it can be used.

As for the electricity industry, the capacity is limited by $K'_1(t)$ so that in the first and second years $X_1(t)$ cannot exceed $K'_1(1)$ which is equal to $K'_1(2)$. But in the third year it increases up to $K'_1(1) + \Delta K'_1$ so that $X_1(3) \leq K_1(3) = K'_1(1) + \Delta K'_1$. Keeping these in mind and ignoring the foreign trade terms, we have the following system:

$$\begin{cases} X_1(1) - a_{11}X_1(1) - a_{12}X_2(1) - a_{13}X_3(1) & = F_1(1) \\ X_2(1) - a_{21}X_1(1) - a_{22}X_2(1) - a_{23}X_3(1) \\ \quad - I_2(1) - \delta_{21}(1) \Delta K'_1 & = F_2(1) \dots (22.1) \\ X_3(1) - a_{31}X_1(1) - a_{32}X_2(1) - a_{33}X_3(1) \\ \quad - I_3(1) - \delta_{31}(1) \Delta K'_1 & = F_3(1) \end{cases}$$

$$\begin{cases} X_1(1) & \leq K_1(1) \\ b_{21}X_1(1) + b_{22}X_2(1) + b_{23}X_3(1) & \leq K_2(1) - \bar{b}_2 (22.2) \\ b_{31}X_1(1) + b_{32}X_2(1) + b_{33}X_3(1) & \leq K_3(1) - \bar{b}_3 \end{cases}$$

$$\begin{cases} X_1(2) - a_{11}X_1(2) - a_{12}X_2(2) - a_{13}X_3(2) & = F_1(2) \\ X_2(2) - a_{21}X_1(2) - a_{22}X_2(2) - a_{23}X_3(2) \\ \quad - I_2(2) - \delta_{21}(2) \Delta K'_1 & = F_2(2) \dots (22.3) \\ X_3(2) - a_{31}X_1(2) - a_{32}X_2(2) - a_{33}X_3(2) \\ \quad - I_3(2) - \delta_{31}(2) \Delta K'_1 & = F_3(2) \end{cases}$$

$$\begin{cases} X_1(2) & \leq K_1(1) \\ b_{21}X_1(2) + b_{22}X_2(2) + b_{23}X_3(2) \\ \quad - I_2(1) & \leq K_2(1) - \bar{b}_2 (22.4) \\ b_{31}X_1(2) + b_{32}X_2(2) + b_{33}X_3(2) \\ \quad - I_3(1) & \leq K_3(1) - \bar{b}_3 \end{cases}$$

$$\begin{cases} X_1(3) - a_{11}X_1(3) - a_{12}X_2(3) - a_{13}X_3(3) & = F_1(3) \\ X_2(3) - a_{21}X_1(3) - a_{22}X_2(3) - a_{23}X_3(3) \\ \quad - I_2(3) & = F_2(3) \dots (22.5) \\ X_3(3) - a_{31}X_1(3) - a_{32}X_2(3) - a_{33}X_3(3) \\ \quad - I_3(3) & = F_3(3) \end{cases}$$

$$\begin{cases} X_1(3) - \Delta K'_1 & \leq K_1(1) \\ b_{21}X_1(3) + b_{22}X_2(3) + b_{23}X_3(3) \\ \quad - I_2(1) - I_2(2) & \leq K_2(1) - \bar{b}_2 (22.6) \\ b_{31}X_1(3) + b_{32}X_2(3) + b_{33}X_3(3) \\ \quad - I_3(1) - I_3(2) & \leq K_3(1) - \bar{b}_3 \end{cases}$$

Using the following notations, we can express this system as follows:

$$b = \begin{Bmatrix} 1 & 0 & 0 \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{Bmatrix} \quad u = \begin{Bmatrix} 0 & 0 & 0 \\ \delta_{21} & 1 & 0 \\ \delta_{31} & 0 & 1 \end{Bmatrix} \quad w = \begin{Bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{Bmatrix}$$

$$I_t = \begin{Bmatrix} \Delta K'_1 \\ I_2(t) \\ I_3(t) \end{Bmatrix} \quad I_t^0 = \begin{Bmatrix} 0 \\ I_2(t) \\ I_3(t) \end{Bmatrix}$$

$$\left\{ \begin{array}{lll} (e - a) X_1 & - uI & = F_1 \dots\dots\dots (23.1) \end{array} \right.$$

$$\left\{ \begin{array}{lll} b X_1 & & \leq K_1 - \bar{b} \dots (23.2) \end{array} \right.$$

$$\left\{ \begin{array}{lll} (e - a) X_2 & - uI_2 & = F_2 \dots\dots\dots (23.3) \end{array} \right.$$

$$\left\{ \begin{array}{lll} b X_2 & - wI_1^0 & \leq K_1 - \bar{b} \dots (23.4) \end{array} \right.$$

$$\left\{ \begin{array}{lll} (e - a) X_3 & - wI_3^0 & = F_3 \dots\dots\dots (23.5) \end{array} \right.$$

$$\left\{ \begin{array}{lll} bX_3 - eI_1 - wI_2^0 & & \leq K_1 - \bar{b} \dots (23.6) \end{array} \right.$$

Denoting $(e - a)^{-1}$ by A and substituting (23.1), (23.3) and (23.5) into the preceding ones, we have

$$\left\{ \begin{array}{lll} b A u I_1 & \leq K_1 - \bar{b} - b A F_1 \\ -w I_1^0 + b A u I_2 & \leq K_1 - \bar{b} - b A F_2 \dots\dots (23.7) \\ -e I_1 - w I_2^0 + b A w I_3^0 & \leq K_1 - \bar{b} - b A F_3 \end{array} \right.$$

Thus, our problem is to maximize our target function subject to these conditions. Note here that, if we try to maximize the national income in the third year, the maximand now is:

$$\Delta K'_1 + I_2(3) + I_3(3) + F_1(3) + F_2(3) + F_3(3),$$

and that our formulation is not at all different from the one of the case in which the gestation period is uniformly one. More complicated cases can be similarly dealt with.

If, on the other hand, the investment of some industry increases its capacity within the same period, then the proportion of that investment which contributes to the capacity must be included in the capital stocks available for production in that period. This case can be treated in the same way.

Introduction of new technologies

Thus far, our discussions have been limited to a natural extension of dynamic input-output system. One industry produces one kind of output with its unique technology. Formulating our problem in terms of linear programming, however, this is not at all necessary. In fact, the development programming must include some method of finding the best technologies to adopt and the best industries to develop.

An introduction of new technologies for the already existing products can be easily brought into our system by simply adding a new activity. Denoting the level of this new activity by X'_1 and its input and capital coefficients by a'_{1i} and b'_i respectively, we have, for example, the following system:

$$\begin{aligned} X_1 + X'_1 - \sum a_{1j} X_j - a'_{11} X'_1 - I_1 &= F_1 \dots\dots\dots (24) \\ X_i - \sum a_{ij} X_j - a'_{i1} X'_1 - I_i &= F_i \quad (i = 2 \dots n) \\ \sum b_{ij} X_j + b'_i X'_1 &\leq K_i - \bar{b}_i \end{aligned}$$

Any further complication may be treated in the same way.

An establishment of entirely new industries must be treated as though originally there were such industries but no production—the “empty” industries. Then, as a result of our optimum choice, these industries will turn out to enter the economy if the entries are advantageous for our target.¹

Linear programming models for economic development

It may be clear by now that development programming must sometimes be formulated in terms of linear (or nonlinear) programming techniques. A dynamic input-output model alone is hardly adequate, for example, to find the optimum path for capital accumulation. This type of formulation

¹ Cf. S. Chakravarty: *The Logic of Investment Planning*, (North Holland, 1959); Chap. VII. See also any standard work on activity analysis.

has not yet been explored very thoroughly.^m Here we shall briefly discuss a few possible ways of formulating linear programming models for economic development.

Any such model must contain: (1) a target function which defines the objective of development programming in terms of relevant economic variables; (2) a set of structural and other relations restricting the possibilities of economic development. One simple example of the former has been given by (18.1), (18.2), (18.4) or (18.5); and that of the latter by (19.5), (20.1) and so on.

Some representative kinds of objectives for economic development were briefly discussed in chapter I. A typical target would be to maximize the national income at the end of the planning period. This does not mean that all the other objectives must be kept aside, because they can be formulated as fixed targets or the conditions to be satisfied in the system. For example, the distribution of national income among regions or professions may be set as the conditions to be imposed upon the optimum solution.

What we took as our target in the formulations above was in fact the maximization of national income with the prescribed menu of future consumption and the limitations by initial capital stocks. This means that we tried to attain the maximum utilization of capital for the purpose of capital accumulation, while meeting the needs for the prescribed pattern of consumption. In other words, the productive capacity of the economic system left after producing consumption goods is used for investment. Since, however, the pattern of investment during the planning period determines the composition of capital stocks, which gives the technical frontiers for the future consumption and investment, there is, one could argue, no reason to evaluate the optimal nature of the composition of capital stocks only on the basis of its total money value. If there is any good reason to give a higher weight to a certain kind of capital good, then

^m The following are the main contribution to this problem:

- (1) Chenery, H., "The Role of Industrialization in Development Programmes", *American Economic Review*, (May, 1955).
- (2) Chenery, H. & Kretschmer, "Resource Allocation for Economic Development", *Econometrica*, (October, 1956).
- (3) Chenery, H. & Uzawa, H., "Non-Linear Programming in Economic Development", in *Studies in Linear and Non-Linear Programming*, (Stanford, 1958).
- (4) Sandee, J., "A Demonstration Planning Model for India", (Mimeographed; December, 1958).
- (5) Nakamura, M. & Okano, Y., "Dynamic Economic Planning and Investment Decision Problem", in *The Annual of Japan Economic Policy Association*, No. 7, (1959).
- (6) Chenery, H., "The Interdependence of Investment Decisions", in *The Allocation of Economic Resources*, (Stanford, 1959).

that capital good should be evaluated more highly than otherwise in our target function. Thus, we must realize that those v_i 's in (18.5) may be changed according to one's judgement about the required composition of capital goods for future production.

This is, however, not the only formulation of our target function. Another way of setting a target would be to seek for the minimum amount of investment for attaining the prescribed level and pattern of consumption within the possibilities of the economic system. Then our target function is exactly the converse of the one above. The solution in this case will show the pattern of investment which is the least requirement for investment to satisfy the prescribed menu of consumption in the planning period. If the pre-assigned level and pattern of consumption is not too great, it may be possible to have some excess capacity in some sectors of the economy while meeting the needs for consumption. Then one might reconsider raising the level of consumption or changing the pattern of consumption. The composition of capital goods at the end of the planning period in this formulation is not necessarily adequate for the future production, because the minimum capital needed for the prescribed menu of consumption only for the planning period may not be large enough in the future. If this is the case and there is any excess capacity in some sectors of the economy, it may be necessary to reconsider not only the prescribed menu of consumption but also the weights attached to each variable in the target function or some of subsidiary conditions concerning fixed targets. In practice, therefore, it would probably be advisable to find the solutions for some typical target functions and, comparing the solutions with each other, determine the best economic plan.

As for the restrictive conditions, the most representative set seems to include the following relations:

- (1) A set of production functions relating to the requirements for current inputs, labour, capital and other inputs to the level of economic activities;
- (2) Specifications of the scarce resources;
- (3) The demand functions for exports;
- (4) Additional conditions to be satisfied.

These conditions may be stated as the balance equations or inequalities between one set of variables and another. The mathematical forms, however, must be either linear or quadratic so that they are amenable to the computational techniques available at the moment.

A linear programming model: Model I

Suppose that we want to attain the prescribed menu of consumption and exports with minimum amount of investment. Then, one way of formulating our problem would be the following:

$$\text{Minimize } \sum I_i \dots\dots\dots (25.1)$$

subject to

$$\sum (e_{ij} - a_{ij}) X_j - I_i + M_i = C_i + E_i \dots\dots\dots (25.2)$$

$$-\sum b_{ij} X_j \geq \bar{b}_i - K_i \dots\dots\dots (25.3)$$

$$\sum h_i E_i - \sum g_i M_i \geq -D \dots\dots\dots (25.4)$$

where C_i and E_i are the prescribed levels of consumption and exports; h_i is the price of exports from sector i in foreign currency; g_i is the ratio of import prices to domestic prices in sector i at the given exchange rate (h_i and g_i are assumed to be constant here); and D is the maximum foreign trade deficit. Using the matrix notation no pp.104-105 above, we can write our problem as follows:

Minimize

$$vI \dots\dots\dots (26.1)$$

subject to

$$BM - BI \geq BC + BE + \bar{b} - K \dots\dots\dots (26.2)$$

$$-gM \geq -D - hE \dots\dots\dots (26.3)$$

where v is a row vector $\{1, \dots, 1\}$. We may add some additional conditions bearing on the employment problem. It can be expressed as

$$nX \geq \underline{N} \dots\dots\dots (26.4)$$

$$nX \leq \bar{N} \dots\dots\dots (26.5)$$

where n is a row vector of n_i , which is the labour input coefficient for sector i , and $\underline{N}$ is the minimum requirement for the level of employment, and $\bar{N}$ the maximum labour supply available for increasing production.

Since $X = AI - AM + AC + AE$,

$$nAI - nAM \geq \underline{N} - nAC - nAE, \dots\dots\dots (26.6)$$

$$nAI - nAM \leq \bar{N} - nAC - nAE \dots\dots\dots (26.7)$$

Clearly one of these two equations will turn out to be redundant. Now the solution of this system gives us a combination of I_i and M_i which by (25.2) determines X_i . This gives the optimal pattern of production and imports.ⁿ

A non-linear programming model: Model II

If the values of exports E_i are not pre-assigned as in the model of the previous section but dependent on the export prices h_i , then the condition (25.4) is no longer a linear function but becomes a quadratic function. Such relations between exports and export prices may be written as:

$$h_i = \bar{\varepsilon}_i + \varepsilon_i E_i \quad (\bar{\varepsilon}_i > 0, \varepsilon_i < 0) \dots\dots\dots (27.1)$$

Substituting this into (25.4), we get

$$\sum (\bar{\varepsilon}_i + \varepsilon_i E_i) E_i - \sum g_i M_i \geq -D \dots\dots\dots (27.2)$$

Suppose that, except for this consideration, we follow the formulation of the previous model. Then our problem is:

$$\text{Minimize: } vI, \dots\dots\dots (28.1)$$

subject to

$$BM - BI - BE \geq BC + \bar{b} - K \dots\dots\dots (28.2)$$

$$-gM + (\bar{\varepsilon} + \varepsilon E) E \geq -D \dots\dots\dots (28.3)$$

$$-nAM + nAI + nAE \geq \underline{N} - nAC \dots\dots\dots (28.4)$$

$$nAM - nAI - nAE \geq -\bar{N} + nAC \dots\dots\dots (28.5)$$

This is exactly the non-linear programming problem formulated by H. Chenery and H. Uzawa. (See item 3 in the footnote m). The solution of this system will give us I_i , E_i and M_i which determines X_i . It may be of some practical importance to notice here that this model tacitly assumes no influence of export prices on domestic prices. If, however, the changes in export prices do affect domestic prices, then the valuation of total investment must be changed and v 's in (28.1) cannot be identical as those in the base year. This takes us to another way of introducing non-linear factors into our system. In fact, there are many alternative ways of formulating linear and non-linear programming models. These two examples are offered here merely to exemplify the basic problems involved. The final point to be kept in mind is that a non-linear programming problem may not be solved so that the algorithm as well as the formulation must be worked out within the capacity of computational equipments.

ⁿ If I_i increases the productive capacity, then, as we discussed in the section on "The gestation period in investment," this effect should be taken into account as the increase in K_i .

Appendix to chapter VI

MULTI-REGIONAL AND MULTI-SECTORAL DYNAMIC INPUT-OUTPUT MODEL FOR THE MEDIUM TERM

By

JAN TINBERGEN

Symbols

In this appendix an example will be offered of a model which takes into consideration some of the most important relationships between regions as well as sectors in a systematic way. It goes without saying, however, that there are a large number of alternative ways of formulating these relationships, and that in any concrete case the planner must adopt the best formulation of the most important relationships according to factual or statistical evidence.

In order to characterize the variables in the following system, three types of indexes will be used. Time will be indicated by usual subscripts like x_t ; sectors by right upper-scripts like x^h ; and regions by left upper-scripts like ${}^r x$. When a sector (or a region) is indicated, in a general way, a symbol h or h' (or r or r') will be used without any specification of number. The total number of sectors (or regions) is H (or R). In particular, however, the first sector ($h = 1$) will be the transportation sector, whose special position in the system will be explained later. The variables to appear in the model are the following.

- ${}^r x_t^h$: Volume of production of commodity h in region r during period t
- ${}^r p^h$: Price level of commodity h as far as produced in region r
- $\bar{p}^h$: Average price level of h in region r
- ${}^r Y$: Income of region r
- ${}^r S$: Savings of region r
- ${}^r e^h$: Exports minus imports of commodity h from region r
- ${}^{rr'} x^h$: Quantity of commodity h produced in region r and used in region r' for consumption as well as production.

- $x^{hh'}$: Quantity of commodity h used in sector h' (for current production of h') in region r .
- $i^{hh'}$: Quantity of commodity h used for investment in sector h' in region r .

In addition to these symbols some more will be used, standing for coefficients considered given.

- σ : Savings ratio, supposed uniform for country, fixed on basis of macro long-term model and hence given.
- θ : Gestation period, assumed uniform, but can easily be differentiated between sectors.
- T^h : Transportation factor indicating price rise (as a ratio) as a consequence of transporting commodity h from r' to r .
- $a^{hh'}$: Input coefficient of commodity h for producing h' in region r
- $k^{hh'}$: Input coefficient of commodity h for expanding capacity of production of h' in region r
- γ^h : Marginal propensity to consume h in region r
- $\tilde{c}^h$: Intercept of Engel curve for good h in region r [cf. equations (2)]
- ξ_0, ξ_1 : Coefficients indicative of price competition between regions in demand functions [see equation (9)]
- $\pi^h, \Phi_1^h, \Phi_2^h$: Coefficients entering into demand functions in the world market for commodity h supplied by region r .

Equations

The equations representing the relations among these variables can be subdivided into ten groups; each group represents a certain category of equations, briefly characterized by its title in the following list. The number of equations in each group is shown at the right-hand end.

(1) Balance equations: $x_t^h = \sum_r x_t^h$ R.H.

(2) Balance equations; for $h = 2 \dots H$:

$$\sum_r x_t^h = \frac{\gamma (Y_t - S_t)}{\bar{p}^h} + \tilde{c}^h \frac{\sum_h \bar{p}^h}{\bar{p}^h} + \sum_{h'} x_t^{hh'} + \sum_{h'} i_t^{hh'} + e_t^h \dots R(H-1)$$

for $h = 1$:

$$(2') \sum_r {}^{rr}x_t^1 \cdot {}^r p_t^1 = \sum_h \sum_r {}^{rr}x_t^h \cdot {}^r p_t^h ({}^{rr}T^h - 1) \\ + \frac{{}^r \gamma^1 ({}^r Y_t - {}^r S_t)}{{}^r \bar{p}^1} + {}^r \tilde{c}^1 \dots\dots\dots R$$

(3) Input equations for current production:

$${}^r x_t^{hh'} = {}^r a^{hh'} \cdot {}^r x_t^{h'} \dots\dots\dots RH$$

(4) Input equations for investment:

$${}^r i_t^{hh'} = \frac{{}^r k^{hh'}}{\theta} ({}^r x_{t+\theta}^{h'} - {}^r x_t^{h'}) \dots\dots\dots RH$$

(5) Financing-of-investment equation:

$$\sum_r {}^r S_t = \sum_r \sum_h \sum_{h'} {}^r i_t^{hh'} \cdot {}^r \bar{p}_t^h \dots\dots\dots I$$

(6) Definition-of-income equations:

$${}^r Y_t = \sum_h {}^r p_t^h ({}^r x_t^h - \sum_{h'} {}^r a^{hh'} \cdot {}^r x_t^{h'}) \dots\dots\dots R$$

(7) Savings equations

$${}^r S_t = \sigma \cdot {}^r Y_t \dots\dots\dots R$$

(8) Total-demand equations:

$${}^r p_t^h = {}^r \pi^h ({}^r x_t^h)^{-\Phi_1^h} \left(\sum_r {}^r x_t^h \right)^{-\Phi_2^h} \dots\dots\dots RH$$

(9) Distribution-of-demand equations; $h = 2 \dots H$:

$${}^{rr}x^h = (\xi_0 - \xi_1 \cdot \frac{{}^{rr}p^h \cdot {}^{rr}T^h}{\sum_r {}^r p^h \cdot {}^{rr}T^h}) \sum_r {}^{rr}x^h \dots\dots (R^2-R) (H-1)$$

(9') ${}^{rr}x^1 = 0$ for $r' \neq r \dots\dots\dots R^2-R$

(10) Definition-of-average-prices equations:

$${}^r \bar{p}^h = \frac{\sum_r {}^{rr}x^h \cdot {}^r p^h \cdot {}^{rr}T^h}{\sum_r {}^{rr}x^h} \dots\dots\dots RH$$

Relations (1), (3), (4) and (7) do not need any explanation. As for equation group (2), the first two items on the right-hand side represent consumer demand, assumed to be composed of a constant $\bar{c}^h$, plus a term proportional to real total consumption. For this part some conditions must be satisfied to warrant the positive values under all realistic circumstances. In addition, it must be assumed that:

$$\sum_h \gamma^h = 1 \text{ and } \sum_h \bar{c}^h \cdot \bar{p}^h = 0$$

meaning that the sum of consumer's expenditure on each commodity h adds up to total consumption. The second condition above refers to prices so that it could not be met beforehand. Since, however, in our way of using the model, prices come in as pre-determined variables at the stage when all the other variables have to be determined, there is no difficulty in making this assumption.

Equation (5) states that all investment expenditures add up to the total of all savings. In the presence of capital imports, these could be added to the left-hand side of the equation.

Equations (6) are derived from the expressions for net income in each sector:

$$Y^h = x^h \cdot p^h - \sum_{h'} x^{h'h} \cdot p^{h'}$$

Equations (8) state that the price p^h to be obtained for product h in any region r will, as a rule, depend on the quantities, produced in the various regions, of the same commodity, with an influence of the production in the region itself somewhat larger than that of the production in the other regions. Equations (8) reflect the effects of price on total demand for product h produced in region r . This demand is negatively connected with its price and with the quantities produced in other regions. The coefficient π^h represents all other influences and hence depends, among other things, on incomes in the countries responsible for demand. The model is essentially a model for an open country, and assumes very little influence of the country's own income on relative prices.

Equations (9) indicate according to what "key" the total demand $\sum_r x^h$ for commodity h a region r exerts is distributed over the various supplying regions. The decisive variable for this distribution is the fraction appearing in the brackets. This fraction is the ratio of the price charged by region r' (the supplying region) for delivery in region r to the average price charged by all regions (multiplied, for convenience's sake, by R).

The lower the "ratio" or relative price, the larger the quantity taken from that particular region r' . Coefficients ξ_0 and ξ_1 are indicative of the elasticity of this relationship; the higher ξ_1 , the higher the "response" to price differences. The coefficients ξ_0 and ξ_1 must satisfy the condition

$$R\xi_0 - \xi_1 = 1$$

in order that the total taken from all regions r' adds up to exactly the quantity demanded in all.

With regard to the transportation sector, this sector has the same features as the other sectors so far as inputs are concerned; it needs inputs both for current production and for investment (see equations (3) and (4)). As a consequence, it comes into equations (5) and (6) in the normal way, contributing to the country's investment needs and the country's income. Transportation services are not supposed, however, to be demanded by the rest of the sectors in proportion to their outputs or investments; i.e. $a^{1h} = k^{1h} = 0$. Instead, the demand for transportation services depends on the quantities ${}^{rr}x_t^h$ moved from one region r to another r' and on the cost of transportation needed per unit of h ${}^r p_t^h$ (${}^{rr}T^h - 1$) which depends on the distance between r and r' , the price of the product ${}^r p_t^h$ and the care to be given to that type of product. The "laws" governing the quantities moved ${}^{rr}x^h$ have already been expressed by equations (9). It will further be assumed that transportation services are not themselves movable from one region to the other, i.e. ${}^{rr}T^h = 1$ and ${}^{rr}x^h = 0$ for $h = 1$. It follows that for transportation services there is no difference between ${}^r \bar{p}^1$ and ${}^r p^1$.

The model just described may be used in a process of "planning in stages". One possibility consists of the following succession of calculations. It will be assumed that existing productive capacity is always fully used. This implies that at any time t production volumes ${}^r x_t^h$ are all determined by previous investments. It will further be assumed that, on the basis of a simpler model, the rate of savings σ has already been chosen. This then means that the total value of investments is given and since prices are given also [according to equations (8)], the following maximum problem can now be solved so as to determine the individual investment items ${}^r i_t^{hh}$: national income $Y_{t+\theta} = \sum_r Y_{t+\theta}^r$ may be maximized under the side condition that the value of total investments in year t are given. In fact, $Y_{t+\theta}$ depends on three groups of variables for year $t + \theta$: ${}^r x_{t+\theta}^h$, ${}^r p_{t+\theta}^h$ and ${}^{rr}x_{t+\theta}^h$ [cf. equations (6)]. Of these, ${}^r p_{t+\theta}^h$ can be expressed, with the aid of (8), in terms of ${}^r x_{t+\theta}^h$. With the help of (1) and (9), ${}^{rr}x_{t+\theta}^h$ can be expressed in terms of the p 's, which are already expressed

in terms of x^h , and x^h themselves. Hence, $Y_{t+\theta}$ is a function of all $x_{t+\theta}^h$. On the other hand, savings at time t depend on the $i_t^{hh'}$, which can be expressed, with the aid of (4), in $x_{t+\theta}^h$'s; all other variables appearing in S_t are already known. Hence also the side condition is one in $x_{t+\theta}^h$'s only.

Having determined these latter variables so as to maximize national income $Y_{t+\theta}$, we may then use the model for the further specification of production plans in year t . The unknowns in this second calculation are indicated below with their numbers in brackets below them:

$$x_t^h, \quad e_t^h, \quad Y_t, \quad S_t, \quad x_t^{hh'}, \quad i_t^{hh'}, \quad p_t^h, \quad \bar{p}_t^h$$

$$(R^2H) \quad (RH) \quad (R) \quad (R) \quad (RH^2) \quad (RH^2) \quad (RH) \quad (RH)$$

adding up to $R^2H + 2RH^2 + 3RH + 2R$. The number of equations is $R^2H + 2RH^2 + 3RH + 2R + 1$. The unknowns will, therefore, satisfy one condition, expressing balance of payments equilibrium, or:

$$\sum_r \sum_h e^h \bar{p}^h = 0$$

The model can be generalized as well as specified in a large number of different ways. Since it is meant as an example only, no further details will be given.

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